DRAFT – 2/27/11

RESULTS OF A PILOT NATIVE BEE MONITORING SURVEY PROGRAM USING ARRAYS OF COLORED CUP TRAPS FILLED WITH PROPYLENE GLYCOL

A JOINT USDA FOREST SERVICE / USGS PROJECT

Sam Droege (sdroege@usgs.gov) and Jim Guldin (jguldin@fs.fed.us)

This report documents the results of an initial evaluation of the logistical and biological practicability of using an inexpensive array of cup traps as long-term monitoring stations for bees.

INTRODUCTION

Much has been written about the status of native bee populations in North America both in the popular and the scientific press. The primary theme in many of those reports is that native bee populations have declined. However, to date, such declines have been quantified over large geographic areas only for bumblebees (Cameron et al. 2011). The success of that single paper in measuring those declines is not due to the existence of a statistically sensitive set of surveys but due to the rapid collapse to zero or near zero in some populations of bumblebees. This collapse has created a signal so strong that simple comparisons of capture ratios between current bumblebee surveys and past accumulated bumblebee specimens in museums readily revealed changes despite significant statistical issues associated with using museum specimens as measures of past bee population size.

Rather than simply documenting the post mortem of a possibly fatal collapse of populations, an ongoing monitoring program should provide warning of trends and patterns of change in time to reverse those declines. Realistically, such a monitoring program needs to be inexpensive, deployable across almost any region and habitat in the U.S. and provide a statistical signal of change with as low a variance as possible while providing an unbiased reflection of change in bee populations.

For the past 10 years researchers have been testing techniques that could meet the above criteria. An evolution has occurred from traditional netting to the use of pan traps. Pan traps are colored (yellow, blue, white) bowls, cups, or pans that are filled with a liquid with low surface tension. Bees are attracted to the color of the trap and drown in the liquid and afterwards are removed, processed, and identified. Since traps are passive the influence of the skill of the observer (such as in netting bees) is removed and traps can be tended by anyone. The recent use of propylene glycol (not toxic to wildlife) as a long-term slowly evaporating liquid in traps now permits the deployment of such traps for weeks rather than days. Many researchers, research groups, and citizen volunteers contributed to this evolution and has led to the techniques piloted below by a group of USDA Forest Service Experimental Forests and Ranges in 2010. The acknowledgements at the end list a number of people who have made significant contributions.

This report details a piloting of glycol trapping arrays for Native Bee populations, summarizes the results, discusses the experiences and outcomes of those results, and makes recommendations for further use of this technique.

STUDY AREAS

Twelve USDA Forest Service EFRs were initially chosen (Table 1, Figure 1) to act as pilots. Candidate sites were identified through the USDA FS EFR Working Group, a standing committee of EFR scientists that deal with issues of national coordination of EFRs for purposes such as this study. The sites were specifically designed to cover as broad an ecological range as possible and included sites in the states of Minnesota, Maine, Texas, Georgia, Colorado, Idaho, California, Ohio, Utah, Oregon, and the

territory of Puerto Rico.

Figure 1

Table 1

Site	Full Name	State	Latidude	Longitude
VFEF	Vinton Furnace Experimental Forest	OH	39.192111	-82.404848
GBER	Great Basin Experimental Range	UT	39.3189	-111.4699
GLEES	Glacier Lakes Ecosystem Experimental Site	CO	41.3645162	-106.23996
PEF	Penobscot Experimental Forest	ME	44.879	-68.6528
MEF	Marcell Experimental Forest	MN	47.5308	-93.46903
HEF	Hitchiti Experimental Forest	GA	33.05092	-83.716464
SFAEF	Stephen F. Austin Experimental Forest	TX	31.50114	-94.76388
PREF	Priest River Experimental Forest	ID	48.3517	-116.84
SDEF	San Dimas Experimental Forest	CA	34.?	-117.?
HRAEF	H.J. Andrews Experimental Forest	OR	44.2118	-122.256
IITF	Luquillo Experimental Forest	PR	18.389346	-66.055275

At each site a circular array of 9 traps (Figure 4) was established. The location of each site was up to the Station and locations varied from natural sites, sites associated with weather stations, to sites that were in lawn areas near headquarters. Sites used locally available propylene glycol which ranged in formulation from RV grade, automotive, plumbing, and commercial. Spacing of traps varied among stations and each station developed their own system for tending traps, minimizing trap disturbance, and dealing with local issues (e.g., Figure 4 demonstrates a local solution to protection from downpours). Blue Dawn dish detergent was added to the glycol to cut surface tension and glycol was added periodically to traps to account for evaporation of the water fraction. Specimens were strained out of these traps approximately every two weeks, placed in whirl paks and shipped to USGS Patuxent Wildlife Research Center for processing and identification. The appendix contains the full protocol and recommendations for changes to processing, traps, and protocols are made in the recommendations section.

Bee specimens were sent to the USGS Native Bee Inventory and Monitoring Lab (BIML) in triple wrapped whirl paks in which the glycol had been drained but the specimens remained damp. At the lab the specimen's bags were assigned a unique 4 digit number (Table 2), clearly labeled, and placed in the freezer until they could be processed. The 4-digit code was used to track the collection event's progress through the system and different colors were assigned to collection events based on whether they were in the freezer, washed, pinned, labeled, or identified to genus. All specimens were pinned and labeled and provided with a unique individual 6-digit number. Specimens will ultimately be dispersed back to the BIML synoptic collection, to the Smithsonian, back to the sites, and to specialists. A commitment was made to identify all specimens to genus, but not to species. All Bombus will be identified to species as will select other groups and sites, depending on time and desire.

Table 2

A	C	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
Site	State	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	Run 7	Run 8	Run9	Run10	Run11	Run12	Run13	Run14
VFEF	OH	7402	7403	7404	7630	7732	7733	7743	7744	7899	7900				
GBER	UT	7631	7730	7731	7705	7706	7888								
GLEES	CO	7713	7714	7715	7793	7794	7795								
PEF	ME	7541	7542	7635	7636	7737	7738	7845	7846						
MEF	MN	7330	7331	7398	7399	7711	7712	7741	7742	7903	7904	7905			
HEF	GA	7354	7400	7532	7533	7707	7708	7709	7710	7856	7857	7940	7941		
SFAEF	TX	7816	7815	7633	7632	7739	7740	7820	7821	7929	7930	7978	7979	7993	7994
PREF	ID	7803	7804	7735	7736	7822	7823	7913							
SDEF	CA	7401	7361	7531	7634	7734									
HRAEF	OR	7866	7867	7868	7869	7870	7871	7872	8006	8007	8008				
IITF	PR	7931	7932	7995	7996	7997	7998	8030	8031						

Figure 2 - PEF

Figure 3 - PEF

Figure 4 - IITF

RESULTS

Table 3 presents totals and averages for each genus across the stations.

Ninety seven separate collections of bees were made by the network of 11 sites (Table 3) with no loss of collection events or sites during the period. These collections resulted in 524 individual genera-by-collection event detections across those runs, and 3587 total bees collected.

Among the sites, SFAEF was the most diligent (and had a long bee activity season) with 14 runs. Interestingly VFEF showed the greatest number of overall detections of genera; an indication of relatively high captures of bees and to some degree the evenness and diversity of bees captured. SDEF, despite the unusual preponderance of honeybees in their captures, ended up with the highest number of genera per run (one factor may be that they only had 5 runs and didn't hit the tail ends of the season where diversity and counts would become lower).

MEF collected the most individuals with very high numbers from the genus Lasioglossum (mostly the Dialictus sub group) and Bombus, but note their rather low ranking in terms of genera per run. This is likely a northern continental effect as continentally the number of genera present in bee communities decreases from the desert SW (the diversity capital for Bees in North America) to the north and east. This

pattern may also be evident from the SDEF's high total of genera (19) despite only 5 runs total.

IITF is a standout in its low totals. This is likely due to the generally lower density of bees present on the Caribbean islands. We have been twice now to Guantanamo Bay on Cuba doing bee bowl surveys and hand collecting. Capture rates there have been about as slow as we have ever seen. Discussions with others who have collected on Puerto Rico, Bahamas, and elsewhere in the Caribbean also back this up, as do numbers of species present (90 on Cuba vs 400 plus in Maryland alone). But it is also possible that the IITF's clever plexiglass rain shade IITF staff deployed may influence the number of bees getting into the traps (Figure 4).

Table 3

Summary of Results By Station

Station	State	# Runs	Genera* Detections	Genera per Run	Rankings Genus	Total Bees	Individuals per Run	Rankings Individuals	Genera Count
GLEES	CO	6	47	7.8	3	418	69.7	3	16
GBER	UT	6	19	3.2	9	243	40.5	6	8
HRAEF	OR	10	70	7.0	5	242	24.2	8	17
HEF	GA	12	60	5.0	6.5	289	24.1	9	17
IITF	PR	6	11	1.8	10	27	4.5	11	3
MEF	MN	11	45	4.1	7	578	52.5	4	11
PEF	ME	8	40	5.0	6.5	218	27.3	7	9
PREF	ID	7	55	7.9	2	530	75.7	2	13
SDEF	CA	5	46	9.2	1	418	83.6	1	19
SFAEF	TX	14	55	3.9	8	203	14.5	10	16
VFEF	OH	10	76	7.6	4	421	42.1	5	18
Total		**95**	**524**	**5.5**		**3587**	**37.8**		

* Number of Genera/run added across all runs

Table 4

USFS Bee Monitoring Sites and Associated States												
	UT	CO	GA	OR	PR	MN	ME	ID	CA	TX	OH	
Genus	**GBER**	**GLEES**	**HEF**	**HRAEF**	**IITF**	**MEF**	**PEF**	**PREF**	**SDEF**	**SFAEF**	**VFEF**	**Total**
Agapostemon	2			1			4	4	10	23	5	**49**
Andrena	2	1		16		28		11		1		**59**
Anthidium									1			**1**
Anthophora	2		1	1				3	8			**15**
Apis	11		10	2	15		2	9	301	19	32	**401**
Ashmeadiella									1			**1**
Augochlora		1	18		8		3				78	**108**
Augochlorella			6				15		1	2	18	**42**
Augochloropsis			1							6	2	**9**
Bombus	308	99	37	7		166	40	335	9	9	26	**1036**
Ceratina			5	40						4	3	**52**
Chelostoma	1											**1**
Coelioxys	1									1		**2**
Colletes		1								1		**2**
Diadasia	6			1				1	2			**10**
Dufourea						1			4			**5**
Epeolus								1				**1**
Eucera						1						**1**
Halictus	7	1	4	50			41	39	12	3	13	**170**
Heriades	1			1							3	**5**
Hesperapis									2			**2**
Hoplitis	5					2					1	**8**

Hylaeus	23	1	2	16		1		2			26	**71**
Lasioglossum	16	127	87	95	4	344	102	71	23	38	196	**1103**
Megachile	4		8	18		9	1	20	4	1	5	**70**
Melissodes	2		41	3			10	25	6	71	9	**167**
Melitoma			7						1	14	1	**23**
Nomada				12		8					1	**21**
Osmia	27	12	4	21		4			1		1	**70**
Panurginus				1								**1**
Perdita									4	6		**10**
Ptilothrix			8							4		**12**
Sphecodes				4		14		9				**27**
Svastra			1									**1**
Trachusa									19			**19**
Xylocopa									9		1	**10**
Total	**418**	**243**	**240**	**289**	**27**	**578**	**218**	**530**	**418**	**203**	**421**	**3585**

GENERA SUMMARY

Honeybees, *Apis mellifera*, are among the most ubiquitous of genera and were found at all sites except GLEES and MEF. SDEF stands out among sites with a very high proportional catch of honeybees; this is likely due to the close proximity of nearby tended hives and perhaps a lack of floral resources. Overall in this study, there are clearly sufficient numbers of honeybees captured across all these sites to consider that this type of system has potential as an independent means of tracking changes in honeybee populations. A network of glycol traps deployed across North America could act as an additional source of status information to the hive counts that are collected by USDA each year. Of possible interest here is that these sites would mix honeybees coming from kept hives with wild colonies and would be a different representation of the status of honeybees than the traditional tracking of hives. Since specimens are collected as part of the survey process, these individuals would be readily available for molecular analyses that could help define commercial, wild, and Africanized

populations.

Bombus is a genus in the same family as honeybees and is our only truly colonial native genus except in the extreme Southwest where native colonial stingless bees sometimes venture northward. Bumblebees were captured in all locations except IITF (Bombus does not occur on Caribbean Islands). This genus and the genus Lasioglossum were by far the most commonly caught groups, making up nearly one third of all captures. Species diversity was great within this group with most sites hosting several species. We are in the process of finishing up the identification of all the Bombus caught to species will provide more details separately. Because of recent widespread documented declines, this is another priority group for USDA and other agencies in terms of tracking their conservation and status. A system of glycol traps holds promise for looking at long-term site trends.

The genus Lasioglossum was the only genus found at every location. This genus contains a large number of species (292 names are listed as occurring in the United States) and it was clear from the captures that many species were involved. It is also true that identification to species is difficult within this group, and at this point, we don't have plans to identify to species all the specimens found.

Halictus is another common Halictidae genus that would be expected at all sites given enough sampling time. They are generalist species and remain common in any open site, whether disturbed or not. They are reasonably easy to identify and we may take the time later this year to do so.

The other commonly caught genera (Megachile, Hylaeus, and Melissodes) all are abundant enough in captures that they too would eventually show up at all of the sites. Spring genera such as Andrena, Osmia, Nomada, and Hoplitis are under-represented in this pilot survey but almost certainly that was simply due to a late start at most sites this Spring.

A lot of the potential power in this type of system will be in documenting trends and patterns in individual species numbers. Despite that obvious attraction for recording species level information, it is also true that identifying specimens to species greatly increases the time burden associated with collecting that level of information as compared to quick, genus level counts. The costs and benefits of making this change are outlined in the discussion and recommendations sections.

COMMUNITY ANALYSIS

A matrix of data from individual 2-week collection events with rows as genera and columns as collection events was submitted to Correspondence Analysis (CA) using the PAST software program (http://folk.uio.no/ohammer/past/). CA is an exploratory data analysis technique that places collection events and genera in a mathematically 2-dimensional space based on similarities among sites. The closer any two collection events plot near each other the more similar their community composition as measured by CA and, in this case, measure by genera totals. It is used here in an exploratory way to look at these preliminary results to get an indication of how similar/dissimilar things may be (at the genus level). Note that a more complete dataset and more complete alignment of events with dates run would be warranted for future analyses.

Symbol legend for each site

GBER (UT) – FILLED GRAY DOT
GLEES (CO) - RED CROSS
HEF (GA) – BLUE OPEN SQUARE
HRAEF (OR) - PURPLE FILLED SQUARE
IITF (PR) - GREEN X
MEF (MN) – OPEN CIRCLE
PEF (ME) - GREEN DIAMOND
PREF (ID) - BLUE STAR
SDEF (CA) - LIGHT BLUE TRIANGLE
SFAEF (TX) - OLIVE RECTANGLE
VFEF (OH) - BRICK VERTICAL PIPELINE

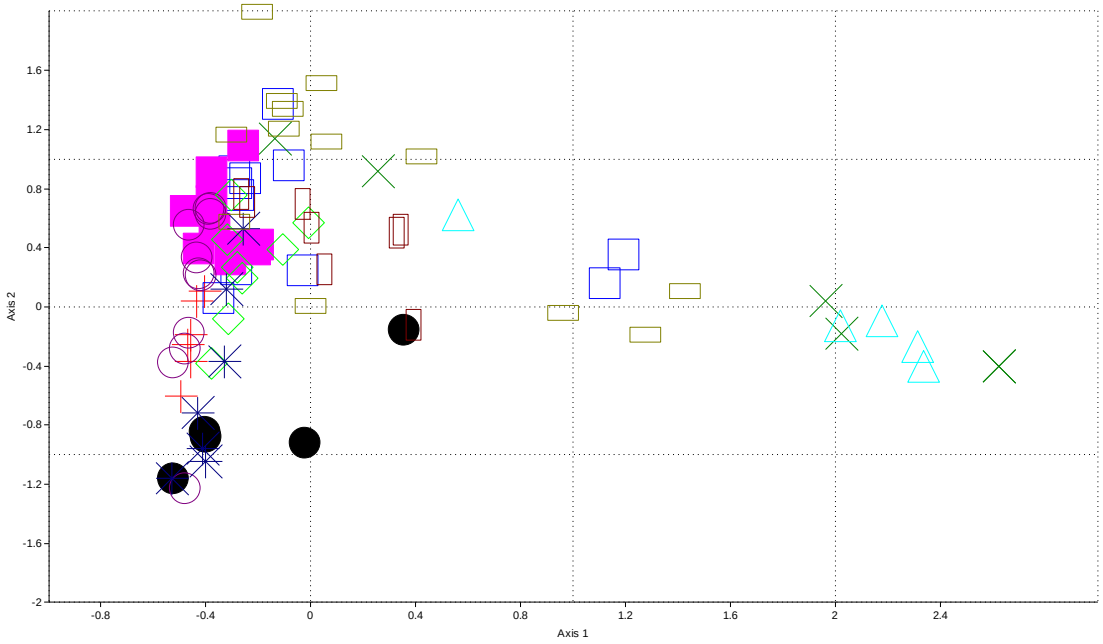

Figure 5 – All data for all sites

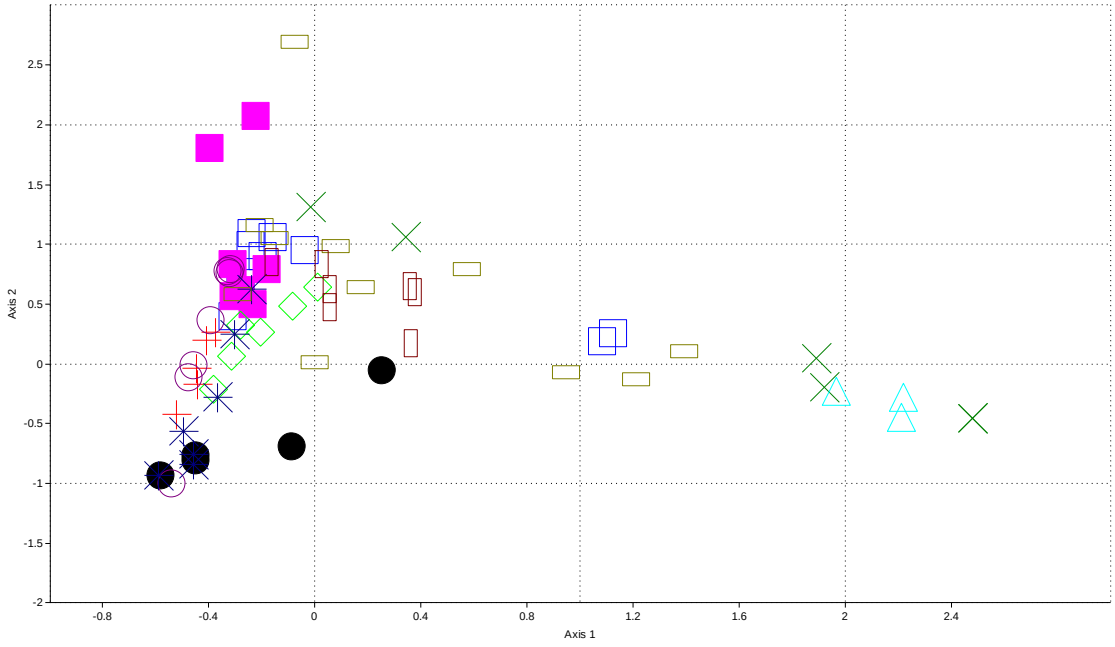

Figure 6 - Ordination with June and early sites removed

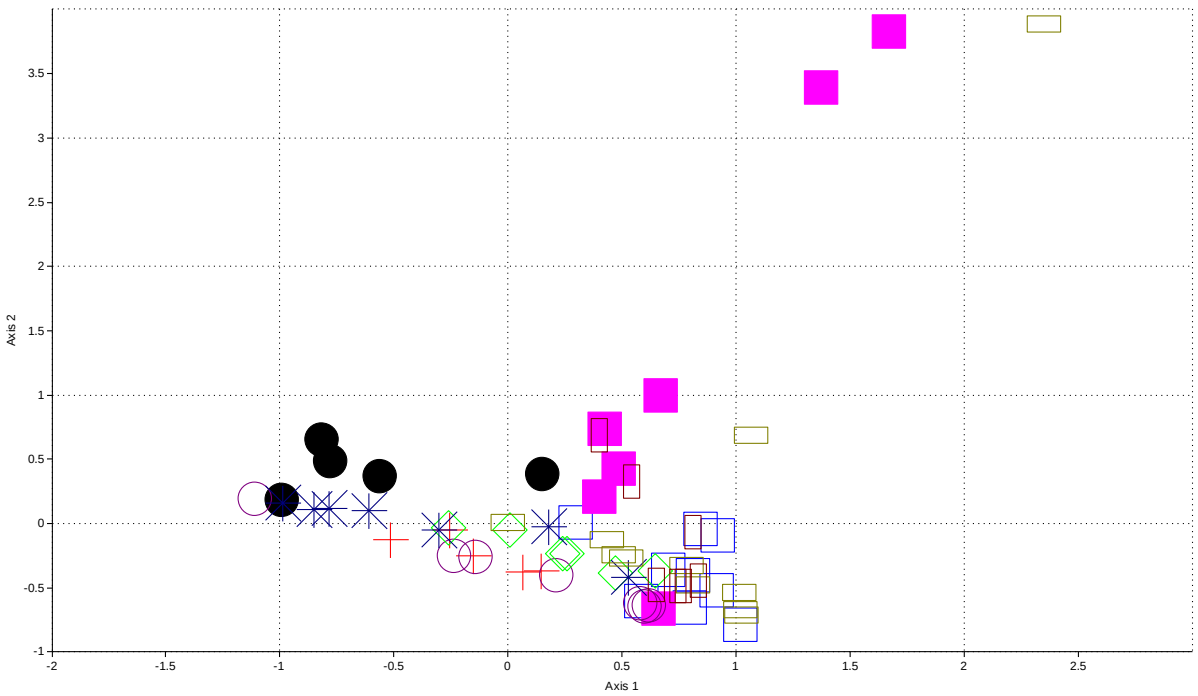

Figure 7 - Collection events prior to July removed along with data from SDEF and PR

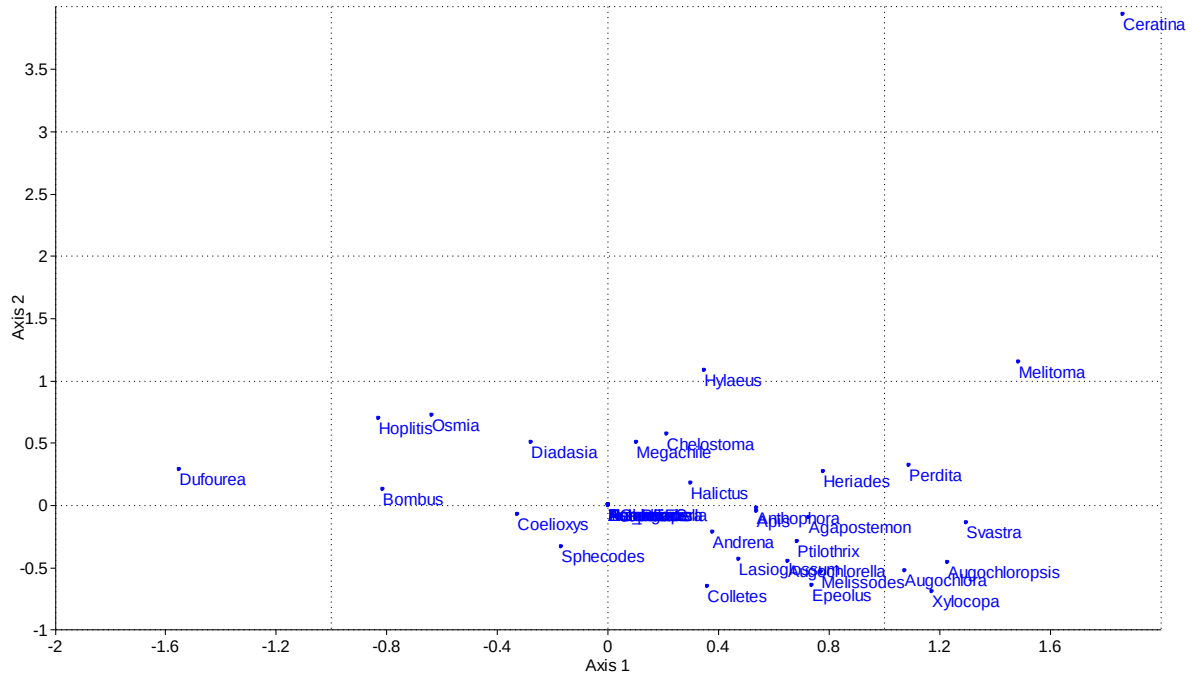

Figure 8 - Bee species centroids mapped into the same space.

Three CA ordinations were undertaken. Figure 5 ordinates all collection events. Figure 6 illustrates an ordination with sites that were collected after June. In this analysis collection events run prior to June were removed because not all sites started their collections until July. Some of the collection events from SDEF and IITF stood out and were isolated far to the right. Both sites had a mix of genera and numbers of individuals that were clearly different from the other sites. In Figure 7 SDEF and IITF localities were removed as well as pre-July sites.

All three figures illustrate that collection events appear to be clustering primarily by location rather than time of year, an indication of consistency of community patterns and captures, at least at the level of genera. Within each of these figures, but particularly the last one where the most collection events were removed, there is a general patterning of eastern sites clustering to the right of the diagram and western sites to the left, though with plenty of overlap.

Figure 8 shows genera plotted in that same ordination space. Thinking of the x-axis as a West to East ordination of plots, the pattern among genera is consistent with eastern sites being associated with the genera Ceratina, Melitoma, Svastra, Augochloropsis, Xylocopa, and Augochlora and western sites associated with the genera Dufourea, Hoplitis, Osmia, Bombus, Diadasia, and Coelioxys.

SUMMARY OF SITE COSTS

The amount of glycol varied greatly across sites from a low of 5L to a high of 24L. Some of reason for this variation was climatological with evaporation rates being clearly higher at some sites. Additionally some of the loss is surely due to the preparation of the glycol used. RV grade glycol is already diluted and the instructions mailed out with this study had everyone diluting their mix by half, so in some cases the mix in traps had a high proportion of water. Water evaporates at over an order of magnitude higher rate than glycol. If we can demonstrate that catch is not affected, it may be worth using undiluted glycol in low rainfall high evaporation locations. Losses will occur with rain dilution, but if cups are topped off with 100% glycol it may ultimately be cheaper. It may also be worth testing type of rain screens used in Puerto Rico to see if they have an impact on capture rates as this should also greatly decrease the glycol needed, though increasing trap costs. One final reason for high rates on some sites may simply be due to the fact that the questionnaire did not mention whether to report the undiluted or diluted rate of glycol use. Note that no specimens appeared to have deteriorated or rotted in any of the various formulations and rainfall dilutions of glycol. Our guess is that, at times, the percent glycol in some of these traps was <25%.

Most sites did not report animal damage and when it was reported it appeared to be either random or due to rodents. In the recommendations we lay out thoughts for improving trap design that would decrease or eliminate rodent problems. At SDEF the array was in a fenced exclosure which was breached by some animal, possibly a bear (or possibly a vandal, though the forest thought this less likely) and all the traps were emptied, but with minimal tooth marks. Likely the need for fencing will have to be made on a site by site basis. Locations within existing enclosures may be useful trap localities. It should be noted that cattle and glycol trap arrays are incompatible simply due to trampling.

Shipping costs varied by location and by carrier. Typical costs for FedEx shipping was approximately $5.00 per monthly shipment. However, if a padded envelope was used and sent regular mail (we have never lost a shipment this way) costs decreased to $1.50/month.

MEF estimated their total costs were $540.00 per summer and included technician times of 9 hours per month, travel costs to the site and shipping.

Most sites thought the burden of running the traps was low, but several mentioned that compensation for some of the costs of shipping, glycol, or technician time would be appreciated. Again, suggestions regarding minimizing costs are made in the recommendations section.

The BIML lab contributed the cost of the traps, shipping those traps, coordinating the project, processing and identifying specimens, databasing specimens and writing this report.

INDIVIDUAL SITE REPORTS

This section documents the activities at each pilot site. For each site the bee results are summarized as well as each site's response to a questionnaire regarding their costs, evaluation of procedures, thoughts on results, and suggestions. Complete questionnaire responses are listed in the appendix.

HITCHITI EXPERIMENTAL FOREST (HEF)

The Hitchiti Experimental Forest Glycol Trap Array was located in Georgia at latitude/longitude 33.05092, -83.716464 at an elevation of 106m. The site was located in the infrequently mown lawn of the Experimental Forest office. No fencing was used and no animal problems were noted with the exception of what appeared to be tooth marks on one cup. Five cups had to be replaced during the year due to cracking. Glycol costs were minimal as the material was already at hand, the amount used was also low and only 1.25 gallons were used the entire season (perhaps because the glycol was not a diluted mix?). Burden was considered low as tending traps was incorporated into other activities.

Google map screen shots below show the landscape surround the array.

Figure 9

Figure 10

Figure 11

Table 5 shows bees captured by bee genus and run number for HEF. Dates for each run number are given in the table below the results.

Table 5

	Run Number												
Genus	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Total**
Anthophora			1										**1**
Apis			1	3		2					2	2	**10**
Augochlora	1		1		4	7	3	3					**18**
Augochlorella		1	3					2					**6**
Augochloropsis						1							**1**
Bombus		6	15	8	2	2	2	1		1			**37**
Ceratina			1		2		2						**5**
Eucera	1												
Halictus	4	4											**4**
Hylaeus				1			1						**2**
Lasioglossum	1	1	19	9	12	16	13	10	1	3	2	1	**87**
Megachile	1	1	7										**8**
Melissodes	3	3	2	6	4	8	5	3	6	3		1	**41**
Melitoma	1	1	3	1		2							**7**
Osmia	4	4											**4**
Ptilothrix		1	4	1		1		1					**8**
Svastra					1								**1**
Total	**16**	**22**	**57**	**29**	**25**	**39**	**26**	**20**	**7**	**7**	**4**	**4**	**240**

Table 6

Date	Run
May 15- June 1	1
June 1- June 15	2
June 15 - June 29	3
June 29 - July 13	4
July 13-July27	5
July 27-Aug.10	6
Aug 10-Aug 24	7
Aug 24-Sept. 7	8
Sept. 7 - Sept. 21	9
Sept 21 - Oct 5	10
Oct 5 - Oct 19	11
Oct 19- Nov.2	12

Twelve trapping periods were returned running from May 15 through November 2nd. A total of 240 bees were captured from 17 genera. Captures in October were very low indicating that the end of September would be a good cut- off date at this site in the future. Several genera were consistently present and those included Lasioglossum, Melissodes, Bombus, and to a lesser extent, Ptilothrix, and Augochlorella. Bombus numbers peaked early and then tapered off and, I believe, were entirely or almost entirely *Bombus impatiens*, the most common eastern Bumblebee and one of the few that remains common fairly far south. As is the case almost everywhere in the country this site had an abundant and diverse group of Lasioglossums, but surprisingly Halictus captures were low. Augochlora is represented by a single species in the East (A. pura) and is a species that nests in downed logs and rotting wood and an indication that such habitats were nearby. Ptilothrix bombiformis is the only eastern Ptilothrix and is a

hibiscus specialist and an indication that marsh associated mallows are nearby or that there are planted gardens with cultivated varieties. This group often will nest in open, and even compacted, soil near buildings. The Melissodes numbers are intriguing as they are a group usually associated only with late summer composites. Because it is an eastern site this we will ultimately identify all the species and thus there will be more information forthcoming.

GREAT BASIN EXPERIMENTAL RANGE (GBER)

The Great Basin Experimental Range glycol traps were located at latitude/longitude 39.3189 -111.4699, at 2,730m in a mountain meadow in central Utah. The traps were located in an existing sheep proof exclosure, but as noted in the comments at the end, these were compromised by cattle towards the end of the pilot and deer and elk had continuous access to the exclosure. Costs and burden we relatively low even though there was a higher than normal degree of maintenance due to trap loss and, at times, dedicated trips were made to tend the traps. It would appear that the primary issues were rodent and perhaps ungulate damage to the traps. Rodent damage appeared to be severe and consisted of traps being chewed. This is similar to my experience on the GTMO base in Cuba where traps were chewed by Hutia (a large Capybara type rodent) if they were left out over night resulting in often severe trap loss. Likely the rodents were more interested in the cups than the contents. The use of a sacrificial cup seems useful. A heavy gauge plastic, glass or metal cup could hold replaceable inexpensive inserts (which would be cheaper to paint from a supply/cost perspective). There was an indication that ungulate were also at least upsetting the traps which indicates that fencing the site may be important....or the use of repellants.

Surveys were run continuously, though with numerous trap losses, from July 19 - September 20.

Table 7

Genus	1	2	3	4	5	Total
Agapostemon	1				1	**2**
Andrena	2					**2**
Anthophora	2					**2**
Apis	5	1	2	3		**11**
Bombus	5	22	44	14	223	**308**

Chelostoma	1					**1**
Coelioxys					1	**1**
Diadasia	4	1			1	**6**
Halictus	2		2	1	2	**7**
Heriades	1					**1**
Hoplitis	1		4			**5**
Hylaeus	5	4	6	3	5	**23**
Lasioglossum	2		2		12	**16**
Megachile		1	3			**4**
Melissodes	2					**2**
Osmia	2	14	10		1	**27**
Total	**35**	**43**	**73**	**21**	**246**	**418**

Table 8

Date	Run
July 19 - August 3	1
Aug. 3 - Aug. 16	2
Aug. 16 - Sept. 1	3
Sept. 1 - Sept. 8	4
Sept8-Sept20	5

Much of the diversity of genera came from the first run. Much of this was likely driven by the project starting here at the tail end of the Spring/Early Summer fauna. This includes genera like Andrena, Anthophora, Chelostoma, Osmia, and Hoplitis. Totals across time for each genus showed relatively low variability, despite the fact that many of these species and individuals have relatively short life cycles of 5-8 weeks. Low

variability is a good thing, an indication that such counts (and, by implication, the populations they represent) have a degree of predictability. The very notable exception are bumblebees, with a very high count of 223 on the last run. Possibly this is due to a production of males at the end of the season as the colony closes down and reproductives are produced for the next season. We are in the process of confirming all the species identifications of Bumblebees and will get back to the group with more insights there. A frustration here is that species identifications were not made so comments about range extensions, species of interest, or other life history patterns are truncated.

GLACIER LAKES ECOSYSTEM EXPERIMENTAL SITE (GLEES)

The Glacier Lakes Ecosystem Experimental Site glycol traps were located in Colorado and were placed at latitude/longitude 41.3645162, -106.23996 with an elevation of 3017m. Habitat around the arrays was subalpine meadow and spruce-fir forest. Approximately 2 liters of glycol were used during the period, with glycol needing to be added to traps about once a month. The array was not fenced and no animal damage was found. The only disturbance was a single lost cup which was replaced. Site maintenance was integrated into other duties and not considered a burden other than the process being a bit messy.

What follows are a series of snap shots at different scales from Google Earth of the glycol array location.

Figure 12

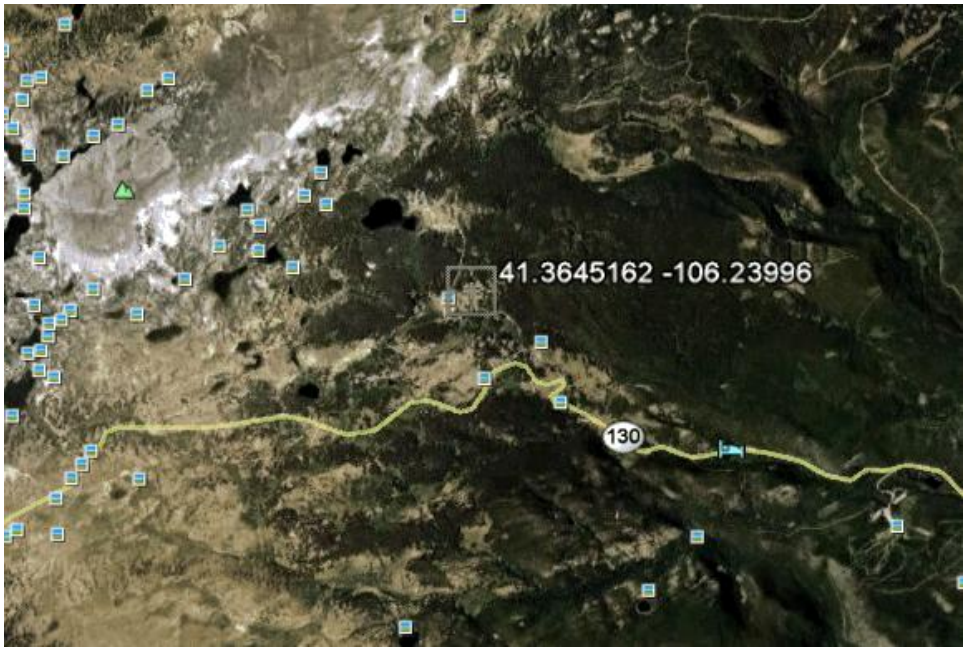

Figure 13

Figure 14

Table 8 below is a listing of captures of bees by genus and by time period. The table below this one illustrates the dates of each sampling period.

Table 9

	Run						
Genus	**1**	**2**	**3**	**4**	**5**	**6**	**Total**
Andrena					1		**1**
Augochlora			1				**1**
Bombus	24	30	7	13	7	18	**99**
Colletes				1			**1**
Halictus			1				**1**
Hylaeus					1		**1**
Lasioglossum	28	38	14	6	5	36	**127**
Osmia	10	2					**12**
Total	**62**	**70**	**23**	**20**	**14**	**54**	**243**

Table 10

Date	Run
June 13- June 29	1
June 29-July 13	2
July 13-July 27	3
July 27- Aug 10	4
Aug 10- Aug24	5
Aug24- Sept14	6

A total of 243 bees were collected across 6 trapping sessions. Eight genera were involved in captures. This is a high elevation site and it is no surprise that there were

almost as many bumblebees (the supertankers of the bee world) as their tiny Lasioglossum cousins captured. Bumblebees have the ability to generate heat by vibrating their flight muscles and are thus active in temperatures other bees cannot fly in. Other than some Osmia residuals from the spring, the diversity of other genera appears to be low. Despite low apparent diversity at the genus level there was a slightly higher than average capture of bees per sampling period compared to other sites.

H.J. ANDREWS EXPERIMENTAL FOREST (HRAEF)

H.J. Andrews Experimental Forest is located in Oregon at latitude/longitude 44.2118, -122.256 at an elevation of 442m. The trap site was located in a natural meadow (Google Maps of the site are printed below) just outside the fence of their meteorological station. Trap tending was done outside of other stations duties, but not considered too great a burden. Glycol was available on site. Shipping was done in a few batches to save postage. There was no apparent animal damage or problems. Some evaporation of the glycol was noted as was dilution during rain events. Traps began cracking at the top across the summer, but only 2 had to ultimately be replaced.

Figure 15

Figure 16

Figure 17

Table 11 below lays out the counts of captured bees across 10 trapping occasions. The dates of those occasions are indicated in the following table.

Table 11

	Run Number										
Genus	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Totals**
Agapostemon	-	-	-	-	-	-	1	-	-	-	**1**
Andrena	10	4	2	-	-	-	-	-	-	-	**16**
Anthophora	-	-	-	-	1	-	-	-	-	-	**1**
Apis	-	-	-	-	-	-	1	1	-	-	**2**
Bombus	-	-	-	-	-	3	2	2	-	-	**7**
Ceratina	4	1	-	1	1	3	4	25	1	-	**40**
Diadasia	-	-	-	1	-	-	-	-	-	-	**1**
Halictus	4	3	7	13	9	9	2	3	-	-	**50**
Heriades	-	-	-	-	-	1	-	-	-	-	**1**
Hylaeus	-	-	-	-	1	2	7	6	-	-	**16**
Lasioglossum	18	6	31	11	6	8	11	3	-	1	**95**

Megachile	-	-	-	-	6	4	5	2	1	-	**18**
Melissodes	-	-	-	1	1	1	-	-	-	-	**3**
Nomada	11	1	-	-	-	-	-	-	-	-	**12**
Osmia	4	5	4	4	1	3	-	-	-	-	**21**
Panurginus	1	-	-	-	-	-	-	-	-	-	**1**
Sphecodes	3	-	1	-	-	-	-	-	-	-	**4**
Totals	**55**	**20**	**45**	**31**	**26**	**34**	**33**	**42**	**2**	**1**	**289**

Table 12

Date	**Run**
May26-June9	1
June9-June24	2
June24-July8	3
July8 - July23	4
July23-Aug11	5
Aug11-Aug25	6
Aug25-Sept14	7
Sept14- Oct3	8
Oct3-Oct19	9
Oct19-Nov2	10

A total of 289 bees were captured across the season. The results indicate that there is little need to extend surveys into October if conditions remain as they were during this field season as only 3 bees were captured in the last 2 trapping periods. Unlike many of the other sites, Bombus was only a very minor component of the overall catch with but 7 specimens detected. It is interesting to note that all specimens were detected in 3 adjacent survey runs, perhaps an indication of a colony nearby or at least an interesting consistency. Further analysis of the species involved will be of interest. This site regularly detects Ceratinas which are small carpenter bees that live in the cut stems of brambles and other woody plants. The larger number of Ceratina specimens in run 8 is suspicious and may represent an inadvertent switching of Lasioglossum and Ceratina totals, those specimens are not handy at this moment, so a double check will have to wait. Halictus and Lasioglossum (both members of the sweat bee group .... Halictidae) were common throughout the period. However, Halictus is likely represented by only 1 or 2 species and Lasioglossum by many. Most are pollen generalists and common in many environments. Andrena and Osmia are spring to early summer bees and many of their group specialize on the pollen of only a single plant genus. Nomada are nest parasites, primarily of Andrena, and were common early in the first run. Late season Megachile is very regular and some in this group are specialists. Again, lots of regularity in the pattern of occurrences of bees which is nice to see.

INTERNATIONAL INSTITUTE FOR TROPICAL FORESTRY (IITF)

The International Institute for Tropical Forestry is located in Puerto Rico at latitude/longitude 18.389346 -66.055275 an elevation of 28m. The trap site was located in a lawn area in front of the institutes main building near their rain guage. The site was a vegetated park-like campus in a largely urban region. Trap tending was done outside of other stations duties, but not considered too great a burden as the traps were nearby, even though trap tending was considered time consuming. Glycol was available commercially but no permanent supply was located. Shipping costs were relatively high and consolidating shipments would be a relatively high cost savings. There was no apparent animal damage or problems except for one cup being disturbed by some unknown element. Due to heavy regional downpours cups were protected from rain by site made Plexiglas shades (Figure 4). As a note, it would be good to test to see if such shades impact the number of bees captured. Significant trap cracking and paint fading was noted and it would be useful to replace cups regularly.

Figure 18

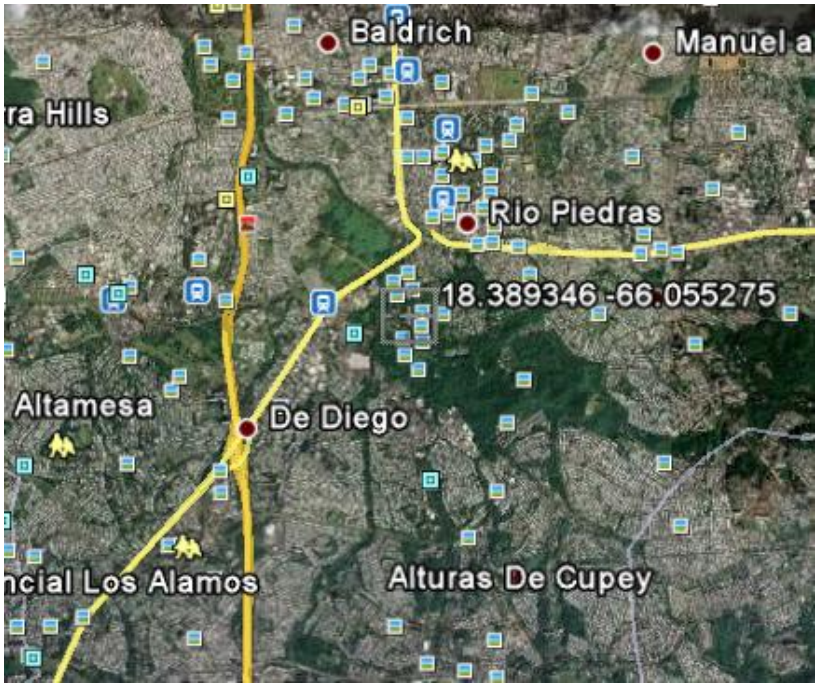

Figure 19

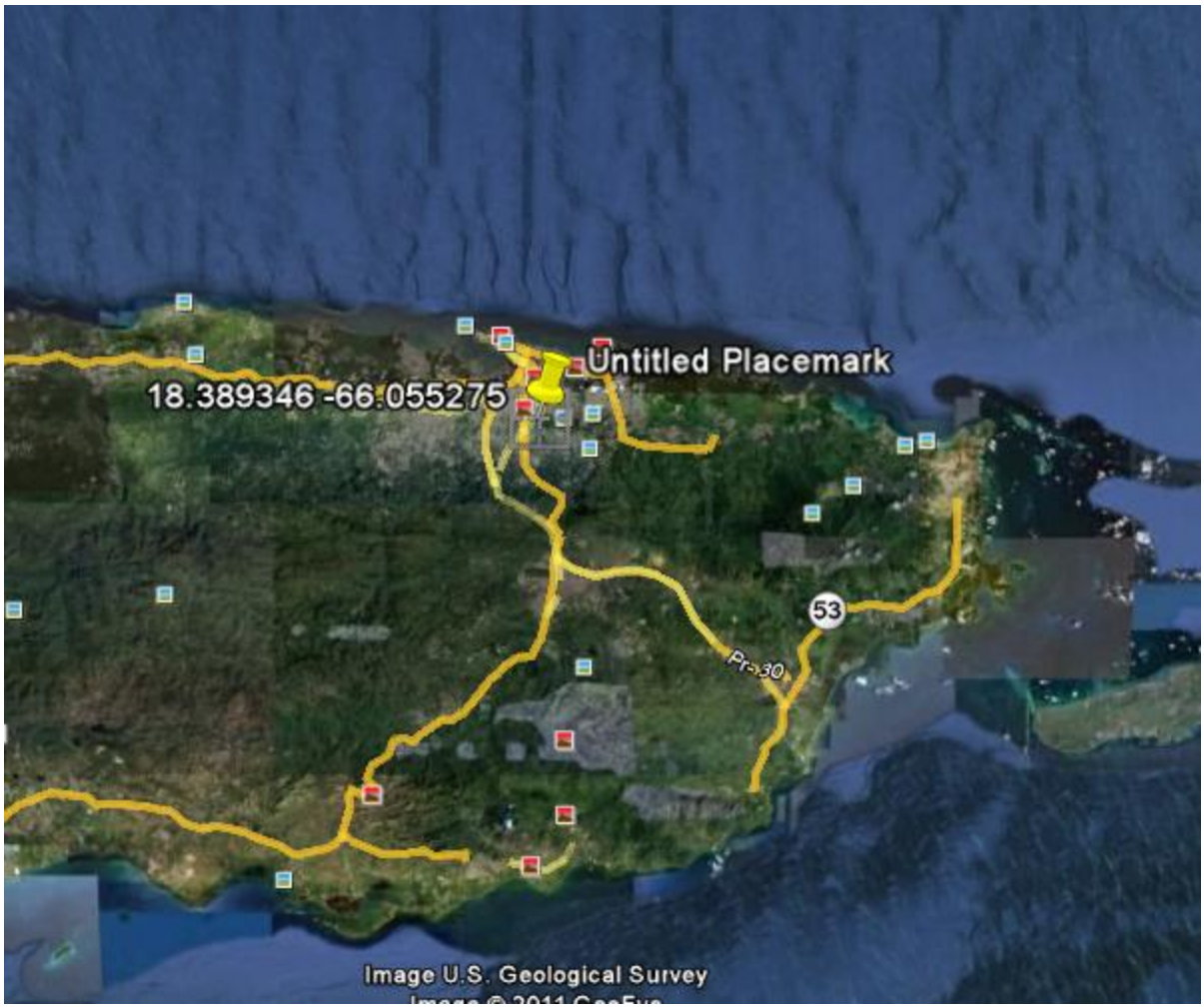

Figure 20

Table 13

Genus	1	2	3	4	5	6	7	8	Total
Apis	1	4	2	2	0	6	5	4	**24**
Augochlora	4	0	0	0	2	2	1	1	**10**
Lasioglossum	2	1	0	0	1	0	3	0	**7**
Melissodes	0	0	0	0	0	0	0	2	**2**
Total	**7**	**5**	**2**	**2**	**3**	**8**	**9**	**7**	**43**

Table 14

Date	**Run**
Sept21 - Oct4	1
Oct4-Oct18	2
Oct18-Nov1	3
Nov1-Nov15	4
Nov15-Nov29	5
Nov29-Dec13	6
Dec13-Dec27	7
Dec27-Jan10	8

The bee fauna's of the Caribbean Islands are quite different from mainland sites in both composition, number of species, and apparent density. In general there are few species, a high rate of endemism (both within island and across the Caribbean) and what often appears to be lower captures per unit effort. Given the above and the fact that this site is located in an urban matrix it is interesting to note that bees were still detected. A 2008 publication (Genaro and Franz) indicates that there are 39 known bee species on the island and that a high proportion are endemics. There is also an indication that more species may be found due to recent discoveries of new and undescribed species. The captures in the glycol trap included Augochlora b***uscki (endemic to the British Virgin Islands and Puerto Rico), Melissodes trifasciata (endemic to Puerto Rico, U.S. Virgin Islands, and Dominica), Honeybees, and a Lasioglossum species which could be one of several found on the island.***

MARCELL EXPERIMENTAL FOREST (MEF)

Marcell Experimental Forest glycol traps were located in Minnesota at latitude/longitude 47.5308, -93.46903 in a grassy clearing in a conifer/peatland forest where their weather station was located. Traps were located about 10-15 m from forest edge. There was no enclosure surrounding the traps or weather station and animal disturbance was minimal with only 1 trap disturbed throughout the system's operation and no major trap issues other than increased brittleness throughout the season (likely

we should replace all traps at least once a year). Traps were run continuously from May 14th until October 15th. Obtaining glycol in the summer was a problem as was efficiently paying for same. Trap maintenance was at times incorporated into ongoing activities but on several occasions required special trips. During hot weather the glycol had to be topped off (if we could go to 100% formulations this problem would disappear, but glycol costs would be higher, however labor costs would presumably drop) also glycol was replaced after major storms (this would be something to consider. If a higher concentration of glycol were used it might be OK if it were diluted during rain events and then topped off as the water fraction evaporated).

Figure 21

Figure 22

Figure 23

Below is a table of the results of the results by genus. Column Headings indicate the sequential run number, the associated dates are listed below the table.

Table 15

	Run Number											
Genus	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**Total**
Andrena	9	5	11	3	-	-	-	-	-	-	-	**28**
Bombus	27	2	9	15	47	32	26	6	-	1	1	**166**
Dufourea	-	-	-	-	-	1	-	-	-	-	-	**1**
Eucera	1	-	-	-	-	-	-	-	-	-	-	**1**
Hoplitis	1	-	1	-	-	-	-	-	-	-	-	**2**
Hylaeus	-	-	-	-	1	-	-	-	-	-	-	**1**
Lasioglossum	12	16	38	46	58	66	80	6	13	54	21	**344**
Megachile	-	-	1	1	2	1	4	-	-	-	-	**9**
Nomada	4	4	-	-	-	-	-	-	-	-	-	**8**
Osmia	3	-	1	-	-	-	-	-	-	-	-	**4**
Sphecodes	-	-	-	1	8	1	1	1	1	1	-	**14**
Total	**45**	**27**	**61**	**20**	**116**	**35**	**111**	**13**	**14**	**56**	**22**	**578**

Table 16

Date	Run
May 14 -May 27	1
May 27 -June11	2
June 11 -June 25	3
June 25- July 9	4
July 9- July 23	5
July23- Aug.6	6
Aug6 - Aug20	7
Aug20 - Sept2	8
Sept2 - Sept17	9
Sept17 - Oct1	10
Oct1- Oct15	11

This site was able to run its traps for much of the bee active season. You can see pulses of early spring Andrena, Osmia, Hoplitis, and Nomada. Megachile are mid-summer bees and there are small numbers present during each mid-season trapping set. Both Bombus and Lasioglossum are present throughout the season. Both of these groups are composites of several species, particularly so in the genus Lasioglossum, where 20 species would not be a surprise. Sphecodes are a nest parasite of Lasioglossum and, as can be seen in the numbers, are consistently present throughout the later part of the season. As can be seen from the map below generated from National and regional databases of bees using data for the uber-common Lasioglossum genus, there is almost no information on bees coming from this North Woods region (the yellow dot near the red cross-hairs is MEF). The numbers nicely demonstrate a consistency in catch at the genus level for individuals in adjacent 2-week intervals. Some very interesting Bombus were initially identified from this site and we will do a complete verification and listing later in the month. If there is time, I hope to identify most of the species here, despite it being slightly out of my normal range for ID's.

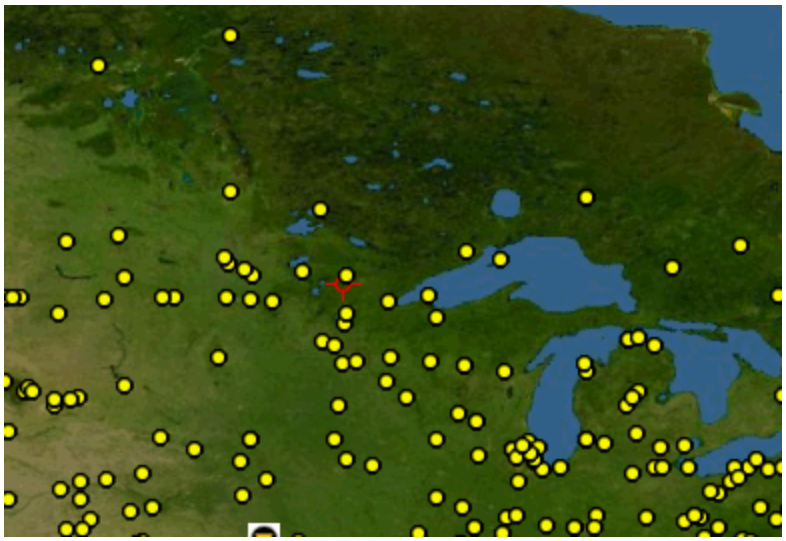

Figure 24

PENOBSCOT EXPERIMENTAL FOREST (PEF)

Penobscot Experimental Forest glycol traps were located in Maine, in an old gravel parking area with lots of weeds and grasses at latitude/longitude 44.879 -68.6528 with an elevation of 31m. One and a half gallons of RV glycol was used throughout the season and no cup damage or replacement of cups was needed, likely due to cooler weather and less intense UV radiation than southern sites. A 2x3x36 inch welded wire mesh 16 gauge fence was added around the traps and no animal disturbance was noted. A special effort to mow and weed around traps was made, but the effort was not considered to be a burden.

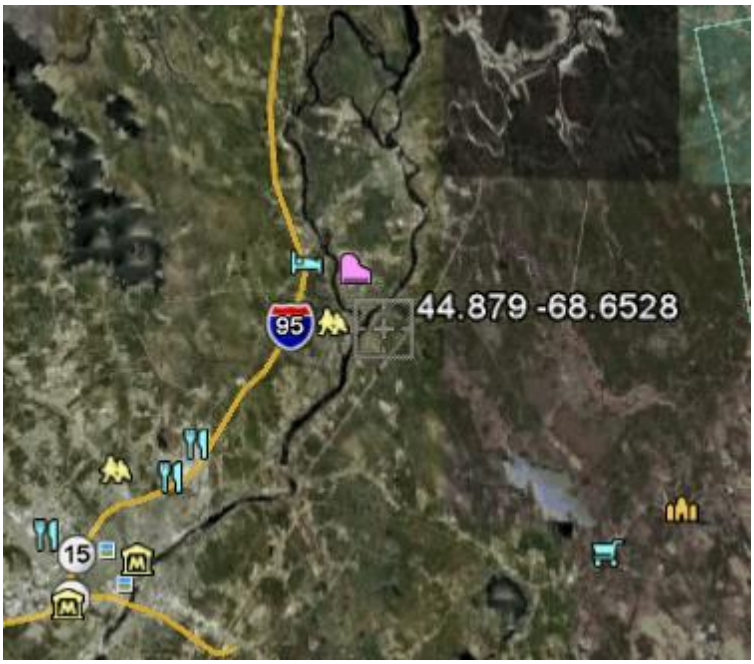

Figure 25

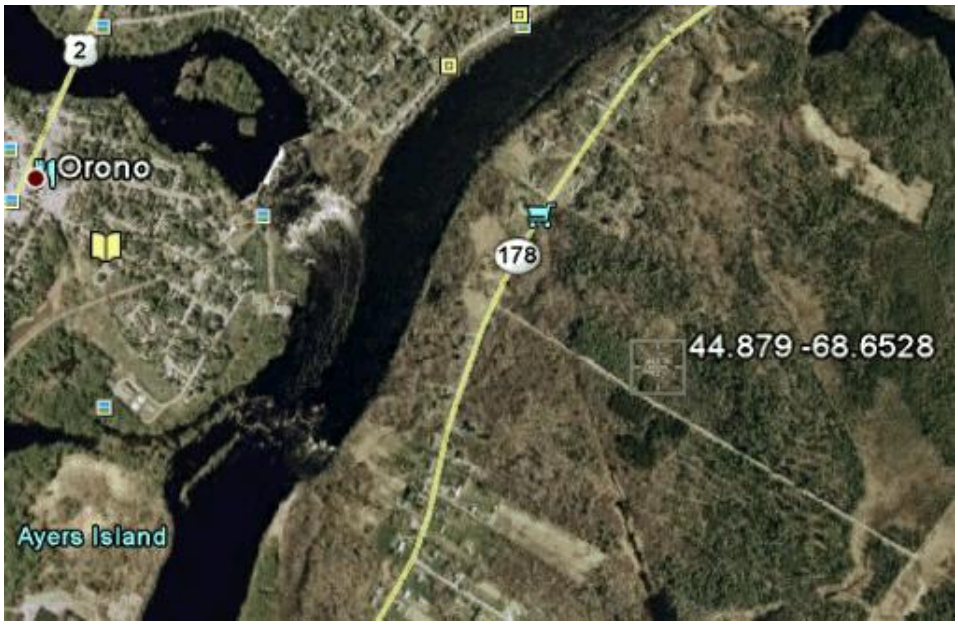

Figure 26

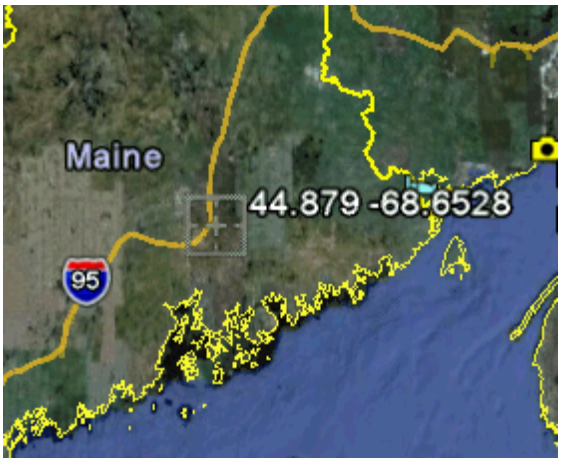

Figure 27

The table below lists results by genus of bee and time period for Penobscot Experimental Forest and the table below that lists the collection dates and associated run number.

Table 17

	Run								
Genus	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Total**
Agapostemon	1	1	2						**4**
Apis						1	1		**2**
Augochlora	2					1			**3**
Augochlorella	4		4	4	1			2	**15**
Bombus		3	7	13	6	2		9	**40**
Halictus	2	5	6	12	7	2	3	4	**41**
Lasioglossum	44	20	10	6	6	7	6	3	**102**
Megachile				1					**1**
Melissodes	1			2	5	1	1		**10**
Total	**54**	**29**	**29**	**38**	**25**	**14**	**11**	**18**	**218**

Table 18

Date	Run
June 7- June 21	1
June 21- July 6	2
July 6 - July 19	3
July 19 - Aug. 2	4
Aug. 2 - Aug. 16	5
Aug. 16 - Aug. 30	6
Aug30 - Sept 13	7
Sept 13- Sept 27	8

Eight trapping periods were completed running from June 7 to September 27. A total of 218 bees were captured from 9 different genera. Lasioglossum and Halictus species were caught in every time period with over half the total captures at the site coming from a wide variety of Lasioglossum species. Even though this is a high latitude site there were still a good number of bees captured in the last time period. Bombus, Melissodes, and Augochlorella aurata were caught throughout the time period in similar patterns to other sites around the country. Also similar to other sites was a pattern of consistency of captures from time period to time period. Jumps in numbers were relatively low. (note to self: I am going to have to figure out how to contrast the variability of counts were are seeing in these glycol traps with some sort of random alternative allocation). Being in the East. This site will also be one we will do species level determinations.

PRIEST RIVER EXPERIMENTAL FOREST (PREF)

Priest River Experimental Forest glycol trap array located in Idaho, at latitude/longitude 48.3517, -116.84 and at an elevation of 730m in the Northern Rockies.

Note that we don't currently have a response to the questionnaire regarding logistical factors affecting this site, but will add it to the final report.

They glycol trap array at the Priest River Experimental Forest, Idaho was located at latitude/longitude 48.3517, -116.84 and at an elevation of 730m in the Northern Rockies.

The following three pictures illustrate the location of the site at different landscape scales.

Figure 28

Figure 29

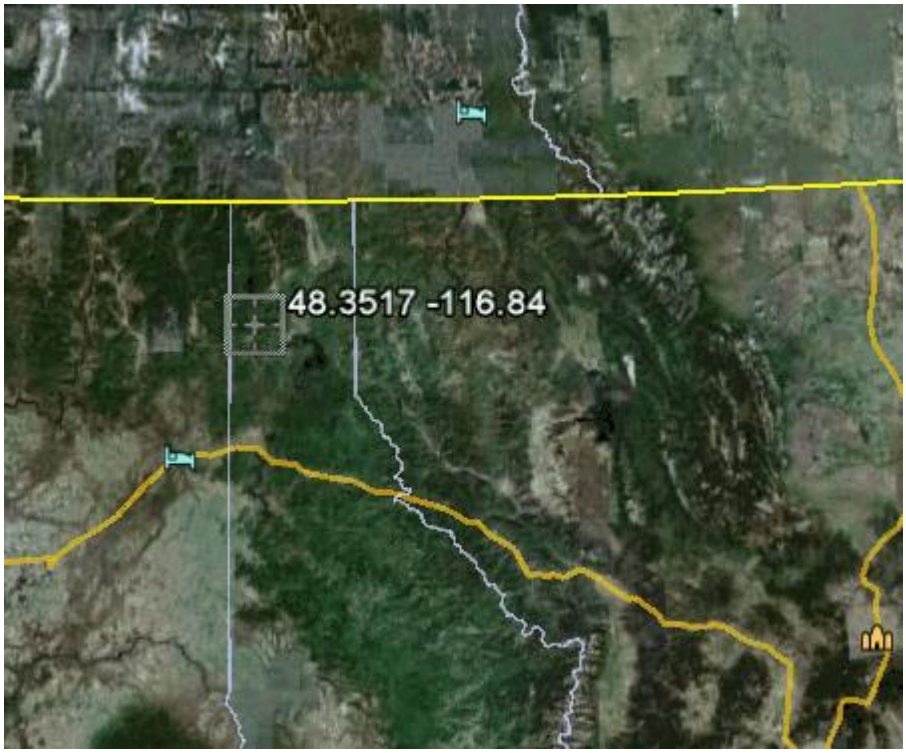

Figure 30

Table 19 below presents that captures of bees from the array traps by genus and trapping period. The table below that documents the dates that each trapping period represents.

Table 19

	Run							
Genus	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
Agapostemon	3						1	**4**
Andrena	6	4	1					**11**
Anthophora	3							**3**
Apis			1	1	5		2	**9**
Bombus	3	11	20	62	102	73	64	**335**
Diadasia							1	**1**
Epeolus	1							**1**
Halictus	9	16	3	1	3	3	4	**39**
Hylaeus		2						**2**
Lasioglossum	40	11	2	1	8	2	7	**71**
Megachile		2	2	11	2	1	2	**20**
Melissodes		4	7	12	1	1		**25**
Sphecodes	3	1	1	1	2		1	**9**
Total	**68**	**51**	**37**	**89**	**123**	**80**	**82**	**530**

Table 20

Date	Run
? - July 19	1
July 19 - August 2	2
Aug 2 - Aug 16th	3

Aug 16 - Aug 31	4
Aug.31-Sept13	5
Sept13-Sept27	6
Sept27-Oct12	7

A total of 530 bees of 13 genera were captured at this site across 7 trapping periods extending from approximately the 1st of July (date not recorded) until October 12th. Members of the genera Bombus, Lasioglossum, and Halictus were recorded in every time period, while Melissodes, Sphecodes, and Megachile were also caught across most time periods. Bumblebees were by far the greatest component of these captures with well over half the specimens coming from this one genus. Despite running until the 12th of October bees were abundantly captured up until the last time period. Unlike other sites this location detected a relatively large and consistent number of Megachile. In general Megachile appear in traps less than their apparent relative abundance. However, since they are large and highly visible species, their rate of capture may actually be consistent relative to other species. The abundance of Sphecodes is also a bit of a surprise. They are nest parasites of bees in the genus Lasioglossum and usually are very uncommon bees in any sort of survey.

SAN DIMAS EXPERIMENTAL FOREST (SDEF)

San Dimas Experimental Forest glycol trap arrays were located in California at latitude/longitude 34, -117. Currently no more explicit coordinates are available due to a problem with translation among formats. A questionnaire is not currently available for this site, but that information will be added later.

Table 21

Genus	1	2	3	4	5	Total
Agapostemon		2	2	5	1	**10**
Anthidium	1					**1**
Anthophora	6	2				**8**
Apis	66		42	57	136	**301**

Ashmeadiella				1		**1**
Augochlorella				1		**1**
Bombus	1				8	**9**
Diadasia					2	**2**
Dufourea				4		**4**
Halictus	2	2	2	3	3	**12**
Hesperapis	1	1				**2**
Lasioglossum	2	10	3	8		**23**
Megachile		4				**4**
Melissodes	1	1	1	1	2	**6**
Melitoma			1			**1**
Osmia		1				**1**
Perdita		4				**4**
Trachusa	3	7	8	1		**19**
Xylocopa		1	1	2	5	**9**
Total	**83**	**35**	**60**	**83**	**157**	**418**

Table 22

Date	Run
June 1 - June 15	1
June 15- June 29	2
June 29 - July 13	3
July 13 - July 27	4
July 27 - Aug 31	5

Five collections were made at this site, with dates starting from June 1st and running

until August 31st. A total of 418 bees were captured across 5 trapping periods. The number of honeybees at this site is striking. Large numbers were found on each sampling occasion except for the second and we have a strong suspicion that this was surely an oversight, but at this point we haven't gone back to the sample to determine that. In the first sample the bees were examined closely and found to have uniformly worn wings, this may be due to stressed individuals being more likely to go to the traps, but a comparison with Honeybee wings from other sites have not been made, and so remains supposition. As noted elsewhere in the report this pattern is likely a consequence of 4 hives being located in close proximity to the trapping site and perhaps few floral resources elsewhere. As further evidence of the unusualness of this pattern, at the BIML lab the USDA honeybee lab is nearby and maintain dozens of hives in our favorite bee trapping sites, yet captures of honeybees are very low. Looking beyond the honeybees its clear that this site has a diverse fauna with 17 genera being represented and many of those with consistent numbers across trapping periods. Of these, several were only found at SDEF including Trachusa, Hesperapis, Ashmeadiella, and Anthidiellum. This pattern is not surprising given this site is the only one located in the drier portions of the Southwestern U.S. where bee diversity flourishes among mountain ranges and the deserts.

STEPHEN F. AUSTIN EXPERIMENTAL FOREST (SFAEF)

Stephen F. Austin Experimental Forest glycol trap arrays were located in Texas at latitude/longitude 31.50114, -94.76388 with an elevation of 70m. Traps were placed in a lawn area near a building which was surrounded by mixed pine/hardwood forest. During the trapping period there was no sign of animal damage to the traps and all traps survived the entire season although with significant fading of some of the colors (likely we should have a standard replacement date for all traps throughout the season). Cost was low and the burden of checking and mailing the traps also low. The primary issue was evaporation of glycol which was significant across several 2 week periods.

Below are Google Maps snapshots of the sampling location.

Figure 31

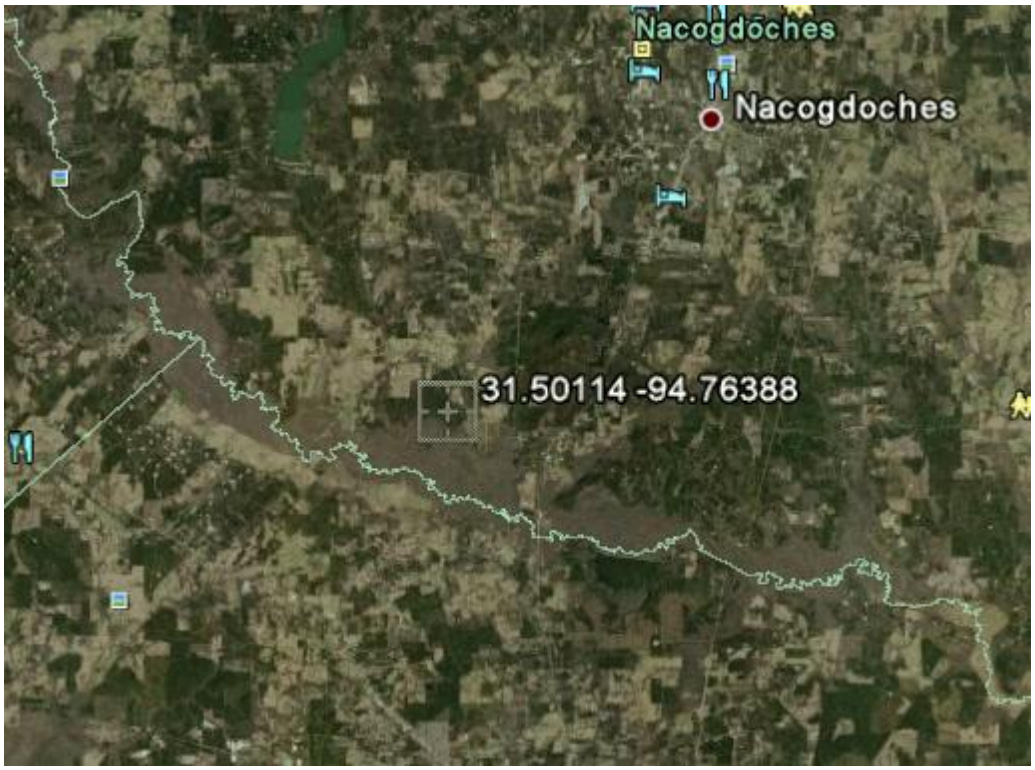

Figure 32

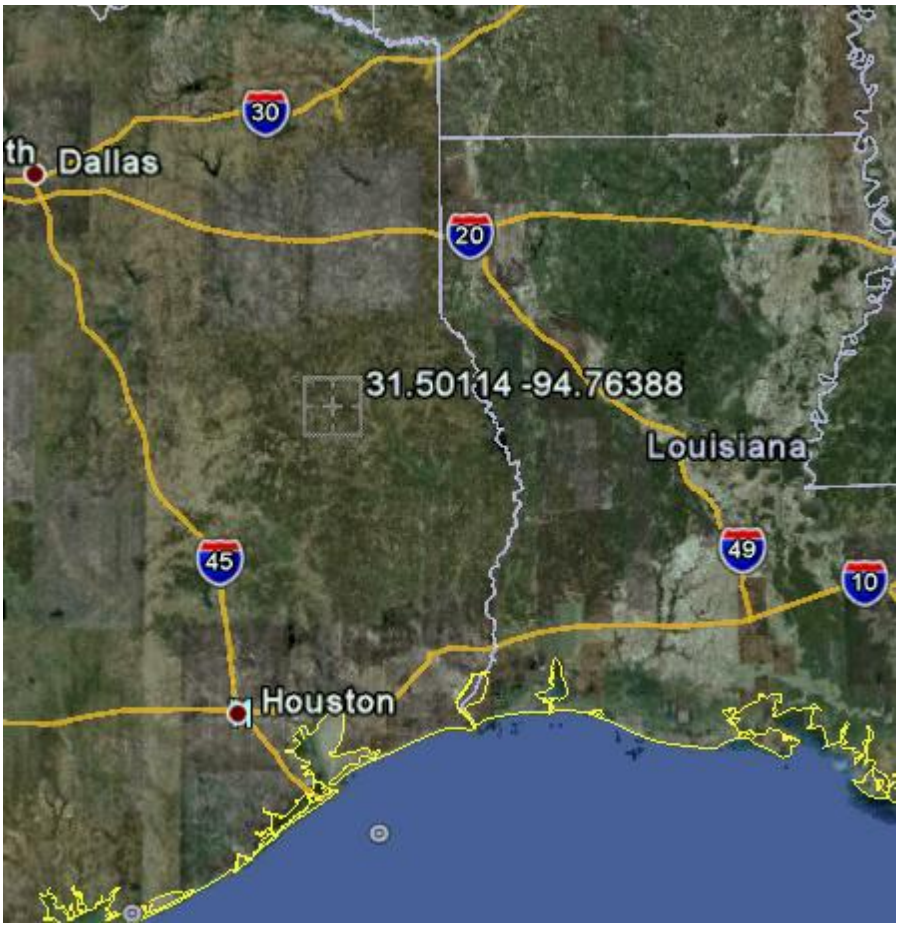

Figure 33

Table 23

	Run												
Genus	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Total**
Agapostemon	9	5		3	3			1			2		**23**
Andrena											1		**1**
Apis					1					3	11	4	**19**
Augochlorella												2	**2**
Augochloropsis	2				1		1	1	1				**6**
Bombus			1	1	1		2				4		**9**
Ceratina	1				1	2							**4**

Coelioxys										1			**1**
Colletes			1										**1**
Halictus											3		**3**
Lasioglossum	20	2	1			4	2	2	2	4	1		**38**
Megachile						1							**1**
Melissodes	17	13	34	5		1				1			**71**
Melitoma	8	3	1		2								**14**
Perdita	2	2		1		1							**6**
Ptilothrix	3	1											**4**
Total	**62**	**26**	**38**	**9**	**8**	**4**	**10**	**4**	**3**	**6**	**26**	**7**	**203**

Table 24

Date	Run
June 2 - June 16	1
June 16- June 30	2
June 30 - 14 July	3
July 14 - July 28	4
July 28-Aug 11	5
Aug11- Aug 25	6
Aug25-Sept 9	7
Sept9-Sept 22	8
Oct6- Oct20	9
Oct20-Nov4	10
Nov. 4-Nov 17	11
Nov. 17-Dec1	12

Results by genus are presented below. Dates for each run are presented in the table below the data array. A total of 203 bees were captured across 12 trapping periods which extended from June 2nd to December 1. Despite the late calendar dates there was no great decline in late season bees until the last trapping date at the end of November. Its also clear that there was a shift in the composition of the catch towards the end of the summer. Melissodes largely disappeared along with Perdita and Ptilothrix captures. All three of these groups tend to be flower pollen specialists and thus this pattern simply represents a disappearance of their food plants. Captures later in the season were relatively low and come from groups whose members tend to be generalists and can get by on the scattered weed species and late blooming natives. The higher capture of honeybees in the late season is perhaps a signal of low floral availability and an investigation by workers of the glycol traps as potential feeding sites. Jack Neff out of Austin has expressed an interest in the species results from this area so likely between the two of us we can get species IDs for this site. The early spring season was completely missed and would have held a large number of additional species and several additional genera.

VINTON FURNACE EXPERIMENTAL FOREST (VREF)

Vinton Furnace Experimental Forest glycol traps were placed at latitude/longitude 39.192111, -82.404848 at 286m in Appalachian Hill Country.

Figure 34

Figure 35

Figure 36

Table 25 below lists bees captures by genus and time period. The table below this one indicates the dates involved with each time period.

Table 25

	Run								
Genus	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Total**
Agapostemon	2	1	1			1			**5**
Apis	1	1	5	10	3	6	2	4	**32**
Augochlora	18	15	6	10	16	8	3	2	**78**
Augochlorella	4	2	5	4	2		1		**18**
Augochloropsis	1	1							**2**
Bombus	4	6	4	3	2	1	3	3	**26**
Ceratina	2	1							**3**
Halictus	2	1	4	2	3		1		**13**
Heriades					1	1	1		**3**
Hoplitis	1								**1**

Hylaeus	2				1	6	8	9	**26**
Lasioglossum	75	40	27	18	23	9	3	1	**196**
Megachile					4	1			**5**
Melissodes	1		1	2	2	1	2		**9**
Melitoma	1								**1**
Nomada	1								**1**
Osmia	1								**1**
Xylocopa					1				**1**
Total	**116**	**68**	**53**	**49**	**58**	**34**	**24**	**19**	**421**

Table 26

Date	Run
June 25- July 8	1
July 8-July 23	2
July 23-Aug.6	3
Aug. 6 - Aug.20	4
Aug. 20- Sept.3	5
Sept. 3 - Sept. 17	6
Sept17-Oct1	7
Oct1-Oct14	8

A total of 421 bees from 18 genera were captured across 8 time periods from June 25th until October 14th. Lasioglossum, Apis mellifera, Augochlora pura, and Bombus were recorded in each of the time periods with nearly half of the captures coming from Lasioglossum species. Halictus, Hylaeus, and Melissodes are also commonly captured groups. This appears to be a diverse site, particularly so given that sampling didn't begin until the end of June after the spring fauna had disappeared (note the absence of any Andrena species).

DISCUSSION

What does this pilot tell us about the potential of this technique to survey native bees?

Before we can answer that question we have to define a successful monitoring program. Here we define success in three ways: 1) a monitoring program that can provide a statistically defensible and biologically meaningful measure of change in the native bee communities of the United States, 2) a program whose long-term cost is sustainable to the funding agencies, and 3) a sample design for which participation is not burdensome to those who collect and process the data.

Based on the experience of the participating stations we feel that with some modification of the protocols and perhaps a small amount of support from the parent agency, establishing monitoring locations at research stations, refuges, visitor centers, park headquarters, and elsewhere is sustainable and would require relatively minor work from participating groups. Suggested modifications are listed in the recommendations section.

Cost for coordinating a network of monitoring locations could vary from low (small number of sites, identification only to genus) to significant (many sites, identification to species). The recommendations section lists several options.

Biological meaningfulness is partially a product of the needs of the participants, the needs of the funding agencies, and the limitations of the statistical design. Below are listed the biologically meaningful products that will or possibly could be produced by a system of glycol traps

SITE LEVEL

1. **A list of the common and some of the uncommon species that occur in the area surrounding the traps**. Over time that list will grow as dispersing bees from the surrounding landscape intersect with the traps. It's unclear how large a sampling region such trap results are representative of and that would be useful future research. This also presumes that species ID is at some point achieved for all the specimens captured.
2. **Estimates of change in bee populations.** Over time, particularly over long periods of time, it will be possible to obtain statistically valid estimates of change in total number of bees, totals by genus, and totals by some of the common species, if species level data are collected.
3. **Specimens.** In order to identify bees even to genus, specimens need to be washed and dried. At minimum all specimens will be archived in petri-dishes and

available to the site and to researchers for work on taxonomy, morphology, DNA analysis, and as educational materials.

REGIONAL AND NATIONAL LEVELS

1. **Estimates of change in bee populations.** In the attached manuscript (LeBuhn et al.) now in journal review we document, in detail, using all the long-term bee datasets available, the behavior and abilities of surveys of bees to track changes under different scenarios. While glycol arrays have not been explicitly tested, they are members of the class of surveys called pan traps, where bees are trapped in some sort of after being lured there by the colors of the traps. The statistical section of this document, as well as the attached manuscript (LeBuhn et al.), document the likely statistical limits of this technique. At minimum, trends can be assessed at the level of total number of bees and total numbers by genus with high statistical power and, if species level data are taken, trends in total number of species, common species and species guilds can be assessed.
2. **Comparative data on bee communities.** Particularly if species level data are collected, it will be possible to associate environmental variables among sites, evaluate similarity among sites, create evaluations of habitat associations for each group; develop trends by ecoregion, by habitat, by guild; identification of regions/ecosystems with greater than average declines and greater than average increases. A good example of the types of data an evaluations that can occur comes from the North American Breeding Bird Survey http://www.mbr-pwrc.usgs.gov/bbs/bbs.html and http://www.pwrc.usgs.gov/library/bibs.cfm.
3. **Specimen data.** All specimens from this system will be archived and even if not identified to the species level will be available into the future for work similar to what was mentioned under the site level information.

Creation of a system that produces statistically defensible data requires philosophical decisions about what is and is not important to us in terms of the types of statements we would like to make about the meaning of any trend data produced by our system of, in this case, bee sampling sites. This is perhaps difficult for most of us to wrap our minds around as it is not integrated into our primary education and its reliance on probabilities requires us to be more philosophical in our thinking than we are used to.

BIAS

One way to think about bias in this context is to think about all the possible ways that the numbers of bees collected from glycol trap arrays may NOT reflect the real numbers of bees in the area or more importantly may NOT reflect real trends in populations. Realistically, there is no known way to directly assess the real trends or the real numbers of bees in the area, consequently, we must use indirect evidence to assess

the situation. Furthermore traditional bias correcting techniques such as mark-recapture techniques are impossible to implement at a level of reasonable cost and sampling for bees nor would they be likely to be sampling the same populations that are being trapped in glycol traps.

There have been a number of studies looking at comparisons of captures across bee survey techniques (see LeBuhn et al. manuscript for many examples). From these we know that colored traps tend to capture bees in different proportions than either malaise samples or netting samples (the 2 most common alternative techniques). Since there is no ability to reference to a "true" population abundance, the differences among trapping techniques remains difficult to assess and only the most dramatic differences are clearly interpretable as important or significant. From these comparisons it is clear that with enough time or sampling locations, most species will end up in a bowl trap. The genus least likely to do so appears to be the genus Colletes which only uncommonly enter in bowl traps. Other common genera enter bowl traps regularly.

What landscape does a bowl represent? Clearly bees that live immediately adjacent to traps are part of the sampling universe. But how far does that universe extend? What sort of probability function describes a bees probability of ending up in a trap if it is located at various distances from the trap? How many of the trapped species are bees that are dispersing rather than bees that are gathering pollen and nesting locally? How does the probability of a given bee ending up in a given bowl vary with its age, sex, nest location, availability of floral and nectar resources, time of day, weather, relationship with the physical and floral landscape surround the traps? All good questions that have not been directly addressed.

While such biasing factors are likely influences in what does and does not enter into a trap on any particular day, in the long run such factors are likely to even out, becoming a component of the variance of counts rather than something that fundamentally changes trend or paints a very different picture of the common species located at a site leading to highly erroneous estimates of how populations are changing at the site. Research is warranted into these factors, but unless bias is very large and the ability to predict and correct that bias is accurate, it is unlikely that that any resulting correction factors will greatly improve the resulting trend estimates.

The monitoring site itself has a great deal of importance in the interpretation of both the sites' trends and the meaning of an amalgamation of trends across all these sites. Trends of bees at any particular site are likely best interpreted as reflecting both populations in the immediate vicinity of the site and what is going on in the surrounding landscapes as these sites are not isolated, but exist within the context of the region's bees. Thus, if trends are desired for a forest, a park, or any landscape, more than 1 monitoring site will be required. The number and distribution of those sites will change

based on the types of data required and it is best to sit down with a statistician to discuss such matters. A good place to start is the Monitoring for Managers Web site (http://www.pwrc.usgs.gov/monmanual/) .

For regional and national estimates of change the interpretation of change has to account for where the sites are located. In this sort of network it is unlikely that true randomness or systematic sampling can be achieved. Thus large scale trends have to be interpreted as trends in the collection of sites chosen and those sites may or may not completely reflect what is going on with bee populations. That said, it should be possible to interpret large scale trends as reflecting "protected" areas, agricultural areas or urban areas, particularly if coordinators attempt to evenly cover sampling across the United States and include representative habitats or locations. Options on how to implement a network of sites is presented in the recommendations section.

RECOMMENDATIONS

Recommendations
For an individual site running glycol traps, expenses fall into 3 main categories: labor costs for tending, mailing, and correspondence associated with trap arrays; cost of glycol for the traps; and cost of fencing, if required.

SITE LEVEL PROTOCOLS

Location. Clearly costs will be lowered if location of a monitoring site is near a location such as a headquarters, visitor's center, weather station or someplace that is visited regularly. Locations need to be in the open. Locating traps in a mown area is probably the most efficient and bees from the surrounding unmown landscape appear to visit such arrays regularly with interference with growing vegetation minimal. A video showing how and where to establish a set of glycol traps is planned.

Trap Design. There seemed to be little problem with the trap holders and they certainly were inexpensive to create. Because traps are expected to periodically be lost, destroyed, and the paint fades with time, it makes sense to have them be relatively inexpensive to replace. A schedule of replacement every 2 months seems reasonable. A more substantial (but still inexpensive) aluminum or heavy plastic cup holder is being sought that will minimize rodent damage and provide more substantial resistance to incidental damage from ungulates and other disturbances. One possibility is to replace the PVC rings used to hold the cups with lengths of PVC pipe that are longer than the cups. The current inexpensive plastic cups would be placed inside these holders.

Number of Traps in an Array. At this point all sites are collecting bees and while more traps will certainly yield more bees and this will increase the catch of rare and

uncommon species it is difficult to say whether this increase would yield a more defensible monitoring dataset. Nine traps seem reasonable in that any trap lost during a trapping time period is balanced by eight other traps and dropping the number of traps to six or three would cause any trap's loss to take on more significance.

Glycol. As mentioned in the discussion section there is likely to be an advantage in either a commercial or centralize set of internet sources of glycol that can be sent out to all sites. It minimizes a site's investments and decreases potential (but unknown) problems with formulations affecting trap capture. To save costs glycol in traps should be reused unless it appears to be highly polluted and darkened by captures. We would like to suggest that uniform, unaltered, and undiluted glycol be made available to sites from a central distribution center, either within the government or from a bulk supplier. While each site generally was able to find glycol it was of varying dilutions, had additives, colorants, and sometimes took significant staff time to simply locate.

Collection of Specimens. Participants had relatively little to say about the process of straining specimens except to note that is was messy and took some time. A video showing options for straining and preparing specimens for mailing would be useful and is planned.

Labeling. The current labeling system, in general, worked well. However, in a few cases, labels deteriorated in the bags and it became difficult to figure out some sample dates and locations. There was a problem at a few sites where pens were used instead of pencils and the glycol erased the information. We are suggesting that labels be sent to each site each year and that they be made out of cardstock.

Mailing. While it makes sense for a new site to mail specimens after the first couple of collections as a double check of their practices, for ongoing sites there is no particular need for mailing specimens over short intervals. None of the specimens shipped were destroyed or had deteriorated. Our suggestion at this point is to do only 2 mailings, one in the middle of the season so that the main office can get a start on processing and one at the end of the season. Mailings should be done through regular U.S mail to minimize costs and a video is planned that explicitly shows how to drain and wrap bags so they do not leak ….which makes people who handle packages nervous.

PROCESSING PROCEDURES

In the BIML lab, efficiency can be gained by processing an entire batch of specimens from one location at once. After washing and drying, specimens can either be placed in drying dishes for future processing or be placed on sorting sheets and processed to genus immediately. The tag from the bag and an assigned 4 digit number then stays with the processed specimens.

Processing to the genus level

- It takes approximately 3 hours for 3 interns to wash and dry 12 collection events.
- It takes about 15 minutes for someone very skilled at identifying species to genus to go through a collection event of specimens, id to genus, and enter into a database.
- Specimens would be returned to a petri dish for archiving

Species level

- It takes about 3 minutes per collection event to database a site's information and assign it a 4 digit code
- It takes about an hour per collection event to sort out and pin bee specimens
- It takes about half an hour per collection event to produce, print, cut, and label specimens
- It takes 2 hours per collection event to ID all the specimens to species (with a few left as unknowns)
- It takes about 15 minutes per collection event to enter the data into a database and check it
- It costs about $5.00 for pins and boxes per collection event

Proposed National Glycol Trap Monitoring System

In our minds, a glycol trapping system would provide the most cost effective and biological feasible monitoring system for native bees to address whether the United States is experiencing pollinator decline. Such a system would have the following characteristics

Nine traps of 3 colors

Trap arrays would be located at sites where a sponsoring site can easily tend them as part of other duties (e.g., near their field office, at a weather station, at a visitor's center)

Fifty sites are recruited from 3 landscape categories

  - Agricultural
  - Protected Natural Areas (including non-plantation forestry operations)
  - Urban

Additional networks can be created for individual agencies or individual sites.

Alaska and Island Ecosystems such as Puerto Rico, Hawaii, and other island territories can be added but it would likely make more biological sense to treat these with separate sampling systems since they are disconnected or distant from the coterminous states.

Similar sites in Canada and Mexico would increase the coverage to all of North America

Sites are chosen to provide systematic coverage with perhaps some (xxxxxx) by physiographic region.

Processing would take place at a set of processing centers

- Each processing center has someone who has been trained and has a verified ability to identify specimens to the genus level.
- All processing centers would archive specimens if species level ID is not made.
- A joint public database would be maintained.

QUESTIONNAIRE RESPONSES

What follows are all the responses received from some of the participating Experimental Forests to a series of questions regarding their experiences.

Hitchiti Experimental Forest

Where did you get you glycol?
We already had two gallons, so did not need to purchase any.

Did you have a problem obtaining/finding glycol?
Yes. I shopped for it in case I needed to buy some more, and could not find it.

How much glycol did you end up using?
Approximately 1.25 gallons

What was the cost of all that glycol?

Roughly how often did you have to add glycol to the traps (assuming they weren't disturbed) ?
A little had to be added every two weeks - a few ounces.

Additional glycol comments?

What was the habitat where you set up the traps?
Mown (infrequently) lawn in front of Experimental Forest office

Was special maintenance required in the area of the traps?

No

Did you set up any fencing around the traps?
No

Did you have any animal problems?
At the last collection trip, I noticed some claw (or tooth?) marks on one of the cups.

How many cups ended up being destroyed over the season?
Five were destroyed due to cracking.

How often were individual cups compromised (e.g., turned over, glycol gone for some mysterious reason, other people disturbed them)?
Every two weeks 1 or 2 cups would be askew, but not enough to spill out all of the fluid.

Did the cups or stands deteriorate over time?
Cups did but the stands held up okay.

How did they do in downpours?
Fine, except they became full of water.

Who tended the traps?
I did (David Combs)

Was trap tending integrated into another task or was it a special trip to pick them up?
Usually I would have other field work to do on the collection days.

How much of a burden was trap tending?....was it considered a PITA?
No burden.

Any other comments/suggestions about traps and trap maintenance/collection?
Probably some better cups.

Can you provide a rough estimate regarding your shipping costs?
$4.01 per month

How much was shipping the specimens once a month?
$4.01

How much compensation from someone (HQ or regional office etc.) do you need to continue a similar system at about the same level of effort?
I think expenses would be low enough that we would not need outside funds, but Mac Callaham could better address this.

Do you have any suggestion on making the system better?
No

Was the listserv and feedback useful/interesting?
Yes

Any comments on the need for survey / inventory data on bees at your station or across USFS lands?
No

Would you be interested in participating another year (likely with a number of changes incorporated)?
Yes

Other comments?

Great Basin Experimental Range (GBER)

Where did you get you glycol?
We had some in storage that is used for winterizing trailers. Can't say where it was purchased.

Did you have a problem obtaining/finding glycol?
No.

How much glycol did you end up using?
I can only estimate. Approximately 10 gallons.

What was the cost of all that glycol?
$60-70??

Roughly how often did you have to add glycol to the traps (assuming they weren't

disturbed) ?
We added a lot because they were almost always disturbed.

Additional glycol comments?

What was the habitat where you set up the traps?
Mountain meadow.

Was special maintenance required in the area of the traps?

Did you set up any fencing around the traps?
Yes. The traps were inside an existing enclosure made to keep out sheep. Cows compromised the exclosure at the end of the season. Deer and elk had access to the exclosure all season and may have been the source of part of our problems.

Did you have any animal problems?
Yes!!! Almost weekly. Probably rodents much of the time but deer or other animals may also have been a problem.

How many cups ended up being destroyed over the season?
Not sure but several. We started puting our colored cup inside a second, styrofoam cup that was easy to replace.

How often were individual cups compromised (e.g., turned over, glycol gone for some mysterious reason, other people disturbed them)?
See the report but generally weekly.

Did the cups or stands deteriorate over time?
Stands were ok. Hard to say whether deterioration of cups was due to general conditions vs animals.

How did they do in downpours?
OK

Who tended the traps?
My techncian, Brian Reeves. I also checked them periodically but on a less frequent basis (monthly).

Was trap tending integrated into another task or was it a special trip to pick them up?

Somewhat integrated but some trips were made specifically for the traps.

How much of a burden was trap tending?....was it considered a PITA?
I did not consider it a burden although it took time and a commitment. This was a pilot study to see the feasibility of a cross-station research effort. There are always risks and opportunities to learn from such an experience. I am pleased when we have opportunities to add value to EF&Rs in this manner so I consider that is was worth it. I would say that though I am curious about the results both for GBER and the wider network, I have no background and training in the field so I don't a real personal/professional interest in all the data. It is nice to be kept informed and at sometime be told of any synthesis of what it all might mean.

Any other comments/suggestions about traps and trap maintenance/collection?

Can you provide a rough estimate regarding your shipping costs?
Sorry, I don't have this.

How much was shipping the specimens once a month?

How much compensation from someone (HQ or regional office etc.) do you need to continue a similar system at about the same level of effort?
The biggest cost is time and vehicle. I'll let Bryce address this if he wants.

Do you have any suggestion on making the system better?

Was the listserv and feedback useful/interesting?

Any comments on the need for survey / inventory data on bees at your station or across USFS lands?

Would you be interested in participating another year (likely with a number of changes incorporated)?
Bryce?

Other comments?

Glacier Lakes Ecosystem Experimental Site (GLEES)

Where did you get you glycol?
Auto parts store

Did you have a problem obtaining/finding glycol?
No

How much glycol did you end up using?
~2 liters

What was the cost of all that glycol?
~$5

Roughly how often did you have to add glycol to the traps (assuming they weren't disturbed)?
Every month
Additional glycol comments?

What was the habitat where you set up the traps?
About half were in an open subalpine meadow, the rest in spruce-fir forest

Was special maintenance required in the area of the traps?
No

Did you set up any fencing around the traps?
No

Did you have any animal problems?
No

How many cups ended up being destroyed over the season?
1

How often were individual cups compromised (e.g., turned over, glycol gone for some mysterious reason, other people disturbed them)?
Once (1 cup)

Did the cups or stands deteriorate over time?
No

How did they do in downpours?
Seemed to be OK

Who tended the traps?
Myself

Was trap tending integrated into another task or was it a special trip to pick them up?
Done along with regular data monitoring

How much of a burden was trap tending?....was it considered a PITA?
Not too much of a PITA, although it was a bit messy.

Any other comments/suggestions about traps and trap maintenance/collection?

Can you provide a rough estimate regarding your shipping costs?
~$25

How much was shipping the specimens once a month?
~$6

How much compensation from someone (HQ or regional office etc.) do you need to continue a similar system at about the same level of effort?
Economics were not really a factor.

Do you have any suggestion on making the system better?

Was the listserv and feedback useful/interesting?
Haven't checked it out yet.

Any comments on the need for survey / inventory data on bees at your station or across USFS lands?
I am probably not qualified to comment.

Would you be interested in participating another year (likely with a number of changes incorporated)?
Yes.

Other comments?

H.J. Andrews Experimental Forest (HRAEF)

Where did you get you glycol?
We use large quantities of glycol in our met stations. I 'borrowed' glycol from that program.

Did you have a problem obtaining/finding glycol?
No

How much glycol did you end up using?
About 3 gallons. We have a lot of evaporation in the summer and dilution in the spring and fall.

What was the cost of all that glycol?
Minimal

Roughly how often did you have to add glycol to the traps (assuming they weren't disturbed)
about one a week

Additional glycol comments?

I was worried about animals consuming the glycol, but didn't see any evidence of that.

What was the habitat where you set up the traps?
It is a small clearing in the forest where our primary met station is located. It is not a natural meadow, which might be preferable. However, there is no way we could maintain a sampling regime at one of our high elevation meadows without a technician dedicated part-time to that task.

Was special maintenance required in the area of the traps?
A bit of hand trimming of herbaceous vegetation around the traps.

Did you set up any fencing around the traps?
I decided to place the traps outside the met station fence to minimize disturbance from met station maintenance activities.

Did you have any animal problems?
None observed.
How many cups ended up being destroyed over the season?
Several were beginning to crack at the very top by then end of the season. Only two had to be replaced during the season.

How often were individual cups compromised (e.g., turned over, glycol gone for some mysterious reason, other people disturbed them)?
Not witnessed. In summer there were times when the liquid evaporated more quickly than I expected, meaning a period with lower than optimal liquid levels.

Did the cups or stands deteriorate over time?
Yes, the cups.

How did they do in downpours?
We don't get the kind of heavy rains that would physically damage cups. We do get periods of several days with constant rain, which dilutes the liquid excessively.

Who tended the traps?
Mark Schulze

Was trap tending integrated into another task or was it a special trip to pick them up?
It was a special task.

How much of a burden was trap tending?....was it considered a PITA?
It wasn't much of a burden, but it was difficult to maintain a rigid two week interval given my travel and other responsibilities during the season.

Any other comments/suggestions about traps and trap maintenance/collection?
It wasn't clear to me when you wanted us to start and stop collection. It would seem to make sense to come up with criteria for starting and stopping collection.

Can you provide a rough estimate regarding your shipping costs?
Costs were low because I shipped in large batches rather than monthly.

How much was shipping the specimens once a month?
Costs would be about $10-15 a month.

How much compensation from someone (HQ or regional office etc.) do you need to continue a similar system at about the same level of effort?
Money to cover shipping would be appreciated. Other than that, the information gathered and the possibility of receiving identified specimens are enough compensation.

Do you have any suggestion on making the system better?
I don't know enough about insect sampling to be able to suggest changes. Some people within our group expressed concern about whether this methodology would be robust enough to allow for analysis of changes over time or comparisons among sites. It seems that it would be important to make sure that the sample design will allow for such comparisons, even if that means a modest increase in effort.

Was the listserv and feedback useful/interesting?
Yes. I only glanced at the updates during the season, but it provided assurance that the samples were of interest and were not going directly into deep storage. The end of season collection information is useful and makes it worth being involved.

Any comments on the need for survey / inventory data on bees at your station or across USFS lands?
There has been some survey work in the past, but we would certainly benefit from

more.

Would you be interested in participating another year (likely with a number of changes incorporated)?
Yes. It would be important to know the specific goals of a long-term program prior to committing to it. For a long-term effort, I would hope that sampling would be robust enough to detect trends over time. For a pilot effort, basic inventory is sufficiently interesting.

Other comments?

International Institute for Tropical Forestry (IITF)

Where did you get you glycol?
Pep Boys Auto supplies. But it was a discontinued item. It was available from Walmart in May/June, but not in August. I suspect also available from a good marine supply store.

Did you have a problem obtaining/finding glycol?
See above.

How much glycol did you end up using?
The experiment was establish September 20, 2010. First collection October 4, 2010- until January 10, 2011

Nine cups X 335ml =3.015L by collection. Eight collections X 3.015=24.12L

What was the cost of all that glycol?
Each gallon bottle was marked at $5.99. But since it was discontinued and not even in the computer system at PepBoys anymore, they sold it to me for $1.00 each.

Roughly how often did you have to add glycol to the traps (assuming they weren't disturbed) ?
We used new solution in every collection (3.015L)

Additional glycol comments?
No

What was the habitat where you set up the traps?
We place the traps around the front side of the main building of IITF in San Juan, near a rain gauge station

Was special maintenance required in the area of the traps?
The area has a monthly maintenance, cut the grass

Did you set up any fencing around the traps?
No

Did you have any animal problems?
No

How many cups ended up being destroyed over the season?
One cup was damage

How often were individual cups compromised (e.g., turned over, glycol gone for some mysterious reason, other people disturbed them)?
One time

Did the cups or stands deteriorate over time?
The paint fade or dissapear

How did they do in downpours?
Ok. No problems

Who tended the traps?
Mary Jeane Sanchez establish the plot. Maribelis Santiago and Carmen Marrero tend and collect the tramps

Was trap tending integrated into another task or was it a special trip to pick them up?
It was a special trip, but it was just outside the office in the Botanical Garden.

How much of a burden was trap tending?....was it considered a PITA?
No, but it takes time

Any other comments/suggestions about traps and trap maintenance/collection?
The cups should be of better quality

Can you provide a rough estimate regarding your shipping costs?
Like $20 a month

How much was shipping the specimens once a month?
Like $20 a month

How much compensation from someone (HQ or regional office etc.) do you need to continue a similar system at about the same level of effort?
Dr.Van Bloem decision. Depends on how the system changes.

Do you have any suggestion on making the system better?
1-Better cups and better paint quality

Was the listserv and feedback useful/interesting?
Yes

Any comments on the need for survey / inventory data on bees at your station or across USFS lands?
No. We don't have an entomologist on our staff, so I don't know what the level of knowledge about bees is here. El Yunque is always happy to have more monitoring occur, but most of the sunny areas are in heavy tourist traffic. The botanical garden is an excellent venue, but may not be completely comparable to experimental forests because it is a green island in an urban matrix. Though that in itself may be interesting.

Would you be interested in participating another year (likely with a number of changes incorporated)?
Yes.

Other comments?
No

Marcell Experimental Forest (MEF)

Where did you get you glycol?
K-mart, Walmart, L & M hardware, Ace (wherever I could find it)

Did you have a problem obtaining/finding glycol?
yes, especially after the last of the winter stock had disappeared from store shelves

How much glycol did you end up using?
Roughly 7 gallons

What was the cost of all that glycol?
$2.79/ gal x 7 gal = $19.53

Roughly how often did you have to add glycol to the traps (assuming they weren't

disturbed) ?
Every two weeks. When it got very warm or we had a lot of rain, the entire cup of glycol was replaced.

Additional glycol comments?
Need to purchase all the glycol in spring before winter supplies run out. If we decide to do this again, let us know as early as possible so we can purchase the glycol while it's still readily available.

What was the habitat where you set up the traps?
grassy clearing in a conifer/peatland forest; cups were about 10-15 m from forest edge

Was special maintenance required in the area of the traps?
grass was cut (as part of weather station maintenance); grass immediately around the cups was trimmed by hand.

Did you set up any fencing around the traps?
no

Did you have any animal problems?
one cup was found cracked; probable animal disturbance

How many cups ended up being destroyed over the season?
one

How often were individual cups compromised (e.g., turned over, glycol gone for some mysterious reason, other people disturbed them)?
just once and we suspect it was an animal

Did the cups or stands deteriorate over time?
They seemed to get more brittle over time; probably should start with a new set of cups if we do this again

How did they do in downpours?
holes in cups kept them from overflowing; glycol was replaced after large storms

Who tended the traps?
Research scientist set up cups, checked samples for extraneous materials, packed samples for shipment; student technician monitored and collected samples during

summer; research scientist monitored cups/collected samples/tore down experiment after student tech went back to school in the fall.

Was trap tending integrated into another task or was it a special trip to pick them up?
During the summer it was occasionally integrated into trips to do other work. Set up, tear down, and monitoring/collecting in the fall required special trips to the field site (1.5 hr round trip)

How much of a burden was trap tending?....was it considered a PITA?
Approximately 44 hours of time went into this project on our part.

Any other comments/suggestions about traps and trap maintenance/collection?
Would be interesting to know if the color of the cup affected numbers trapped. Would be more work to separate samples by cup color but might be worth it.

Can you provide a rough estimate regarding your shipping costs?
$5.70 x 11 shipments = $62.70

How much was shipping the specimens once a month?
Approximately $5.70 per shipment

How much compensation from someone (HQ or regional office etc.) do you need to continue a similar system at about the same level of effort?
Labor = $15.00/hr (tech salary & benefits) x 9 hrs per month (including set up, tear down, travel time, shipment packing time) x 5.5 months = $743. Travel = 90 mi per trip x $0.50/mi x 12 trips/summer = $540 per summer

Do you have any suggestion on making the system better?
It would be helpful to have official funds to cover technician time and expenses. I ended up paying for the glycol out of pocket to avoid having to deal with the extra paperwork associated with not having an account for this project.

Was the listserv and feedback useful/interesting?
yes, very useful. The information that: 1. a rare bee species was collected on our forest and 2. this was a collaborative effort between USFS and USGS was communicated to our team leader, project leader, and an assistant director of our research station during their visit this summer. They seemed impressed with both the rare find and the fact that the two agencies were collaborating on an ecological project such as this.

Any comments on the need for survey / inventory data on bees at your station or across USFS lands?
Very useful data since little to no terrestrial insect data has been collected on our forest over the last 50 yrs. I have just started working on inventorying the the aquatic insect/invertebrate life at MEF.

Would you be interested in participating another year (likely with a number of changes incorporated)?
yes!

Other comments?
As an entomologist myself, I sincerely appreciate the quick turnaround on sample IDs and results (thank you!). Also, the fact that the two agencies are collaborating to monitor a very understudied, undervalued (at times completely unappreciated) group of organisms (arthropods) is great. Would like to see and participate in more efforts of this kind.

Penobscot Experimental Forest (PEF)

Where did you get you glycol?
Walmart

Did you have a problem obtaining/finding glycol?
No problem, it was in the RV section of the store

How much glycol did you end up using?
About 1 ½ gallons

What was the cost of all that glycol?
$8.33

Roughly how often did you have to add glycol to the traps (assuming they weren't disturbed) ?
Once a week

Additional glycol comments?

What was the habitat where you set up the traps?
Old gravel parking area with a lot of weeds and grasses

Was special maintenance required in the area of the traps?
Yes, lawn mowing and weeding around each trap

Did you set up any fencing around the traps?
Yes, 2x3x36 inch welded wire mesh16 gage @ **$42.00**

Did you have any animal problems?
No

How many cups ended up being destroyed over the season?
None

How often were individual cups compromised (e.g., turned over, glycol gone for some mysterious reason, other people disturbed them)?
None

Did the cups or stands deteriorate over time?
No

How did they do in downpours?
Just fine I think

Who tended the traps?
I did

Was trap tending integrated into another task or was it a special trip to pick them up?
It was a special task

How much of a burden was trap tending?....was it considered a PITA?
Was no burden

Any other comments/suggestions about traps and trap maintenance/collection?

Can you provide a rough estimate regarding your shipping costs?
$5.76

How much was shipping the specimens once a month?
$1.44 per shipping

How much compensation from someone (HQ or regional office etc.) do you need to continue a similar system at about the same level of effort?
Just need to get the Okay

Do you have any suggestion on making the system better?

Was the listserv and feedback useful/interesting?
Very interesting

Any comments on the need for survey / inventory data on bees at your station or across USFS lands?
The inventory data is very important to the local people

Would you be interested in participating another year (likely with a number of changes incorporated)?
Very much so

Other comments?

Stephen F. Austin Experimental Forest (SFAEF)

Where did you get you glycol?
We purchased our glycol at Tractor Supply here in Nacogdoches, TX.

Did you have a problem obtaining/finding glycol?
No. Tractor supply had several gallons of glycol in stock.

How much glycol did you end up using?
We used 4 gallons (8 gallons after dilution).

What was the cost of all that glycol?
$3.50 / gallon

Roughly how often did you have to add glycol to the traps (assuming they weren't disturbed)
I added glycol to traps every two weeks; however, on some occasions some of the traps had very little glycol left in them. During most of the season glycol could have been added weekly.

Additional glycol comments?

What was the habitat where you set up the traps?
The traps were placed in the SFAEF near a building in an open lawn area. The surrounding forest is a pine hardwood mix.

Was special maintenance required in the area of the traps?
Grass was removed throughout the study so that it did not grow above traps.

Did you set up any fencing around the traps?
No.

Did you have any animal problems?
Not that I was aware of. On a few occasions one of the traps was tilted somewhat sideways but only a small amount of fluid was lost.

How many cups ended up being destroyed over the season?

None.

How often were individual cups compromised (e.g., turned over, glycol gone for some mysterious reason, other people disturbed them)?
There was never an instance when all of the glycol was gone from a trap. However, on a few occasions during the heat of summer some of the traps had very little glycol remaining in them after 2 weeks.

Did the cups or stands deteriorate over time?
Cups became fragile, but I never had to replace one.

How did they do in downpours?
It appeared that the traps held up well in rainfall.

Who tended the traps?
Myself.

Was trap tending integrated into another task or was it a special trip to pick them up?
I go to the SFAEF every 2 weeks so I tended to traps while I was already there.

How much of a burden was trap tending?....was it considered a PITA?
Once the trap stands were installed very little time was necessary to check and refill traps. Not a PITA.

Any other comments/suggestions about traps and trap maintenance/collection?
I noticed that the colors on the traps faded over time. It may be beneficial to replace cups a few times during the trap season.

Can you provide a rough estimate regarding your shipping costs?
Less than $20 for shipping.

How much was shipping the specimens once a month?
~$2.50 per month

How much compensation from someone (HQ or regional office etc.) do you need to continue a similar system at about the same level of effort?
This is a question for Jim Guldin.

Do you have any suggestion on making the system better?
The glycol evaporates relatively quickly when mixed 50:50 with water. You suggested in a previous email that using pure glycol (no dilution) may be an option.

Was the listserv and feedback useful/interesting?
I was not on the listserv.

Any comments on the need for survey / inventory data on bees at your station or across USFS lands?
Question for Jim Guldin.

Would you be interested in participating another year (likely with a number of changes incorporated)?

Question for Jim Guldin.

APPENDIX. PROTOCOL THAT WAS MAILED OUT TO PILOT SITES.

2010 Set up and Protocol for Pilot Native Bee Monitoring at USFS Experimental Forests and Ranges

Contact for Questions and Problems: Sam Droege W-301-497-5840, F-301-497-5624 (sdroege@usgs.gov)

Mailing Address for Specimens:

Sam Droege

USGS Patuxent Wildlife Research Center

BARC-EAST, BLDG 308, RM 124

10300 Baltimore Ave.

Beltsville, MD 20705

USFS Contact: Jim Guldin 870-723-1623 (jguldin@fs.fed.us)

BASIC DESIGN (MODIFIED FROM THAT CREATED BY DAVE SMITH IN USFWS)

- 9 traps of (3 of each of 3 colors) are placed around a weather station (or other convenient sample site typical of regional conditions)

- Traps are kept filled with propylene glycol up to the level of the small overflow holes at the top of the cup and captured insects strained out every 2 weeks
- Labeled and bagged insect specimens are sent once a month to Sam Droege at the address above

SETTING UP TRAPS FOR THE FIRST TIME

A trap consists of a holder made of plastic conduit with a ring screwed to it that holds a plastic cup and looks similar to that below.

These traps can be set up by pounding the plastic conduit into the ground directly (if the ground is reasonably soft). If the ground is hard a short piece of rebar can be pounded into the ground and the conduit slipped over the rebar. After pounding in, plug the conduit with dirt or rocks so that bees and other critters don't climb in and can't get out.

HEIGHT AND LOCATION OF TRAPS ARE VERY IMPORTANT

- Traps need to be in the open, exposed to full sunlight and not overhung by trees or grass and forbs during the trapping season. Bees see things differently than we do and don't resolve things in the shade very well. Bottomline: Traps in shade = no bees
- Traps can be kept in grassy mown areas, but care should be taken not to let them get filled with grass clippings
- The height should be set so the bottom of the cup is just above the level of the ground (note that this is lower than shown in the picture above)
- Traps should be spaced evenly around the perimeter of the weather station. While spacing is not absolutely critical it would be good if they could be somewhere between 5-20m apart. Also keep in mind that these sites should be considered permanent throughout the season and perhaps into upcoming years, so think ahead. If there are questions, sketch the rough arrangement on a sheet of paper, and FAX it (or scan and e-mail it) to Droege for comments. You can write the trap number on the ring if that is useful for keeping track of where the traps are

CUP TRAPS AND TRAP FLUID

- After the trap holders are pounded into the ground, place a cup in each (alternating the colors)
- Fill each cup up to the holes under the rim with diluted propylene glycol (50-25 Water:50 propylene glycol) mixed with detergent
- This mixture lasts for weeks in even dry conditions, however, some evaporation of the water component can be expected so once a week check and top off as needed (lower fluid levels decrease the catch)
- Propylene glycol—sources, mixing, and additives:
    - There are 4 main local sources of PG
        - Walmart and sometimes Home Depot (as red-colored RV antifreeze…likely only available in the fall)
        - Swimming pool supply stores
        - RV centers
        - Heating and cooling supply stores (they usually have to order it for you)

    - Note that outside of fall and winter the stores may have to order this material so do some calling around first
    - On the other hand, RV and Marine antifreeze is easy to buy online
    - Two gallons should be fine for the season
    - If it comes red (rather than blue) you can get rid of the red color by adding a tablespoon or two of household bleach and shaking, in a couple of hours it will be completely clear
    - The red antifreeze can be diluted by half, the stuff from heating and cooling supply stores (usually blue) maybe be full strength (ask) and can be cut by two-thirds. The blue color does not go away even with bleach, but does not affect capture rates
- Be sure to add a large squirt of BLUE DAWN or UNSCENTED liquid dish detergent to each gallon before and gently mixing…other detergents (particularly citrus-scented ones) repel bees. Note that DETERGENT is important in this mix or bees will simply land on the glycol's surface tension and fly off

STRAINING THE CATCH OUT

Every 2 weeks, the sample is strained and the catch put in labeled whirlpaks, using the following procedure.

- Remove the cup from the hoop
- Pour contents into a brine shrimp net under which is a small bucket or bowl to catch the strained glycol
- Put some extra glycol into the bucket when you start so that you can refill all the cups to the top
- Refill the cup and put it back into the trap holder
- Repeat for all cups (note that each cup's catch is simply added to the net to create 1 pooled sample)
- Note any traps that have been disturbed or destroyed in a such a way that the contents are gone or unusable…AND NOTE IN THE LOG…so we can correct for different numbers of traps during analysis
- As you go along throw out all butterflies, slugs, snails, grasshoppers and plant material or anything that looks like it will gook things up. All the other insects are fine to leave in as we will sort them in the lab

BAGGING

- Use a plastic spoon to scoop the bugs out of the net and place into a whirlpak
- Add a site label (print from the provided Excel sheet) with the site name and dates collected
- Add a SMALL amount of glycol to cover
- Did we mention only using a SMALL AMOUNT?....the Post Office is not happy with leaky bug bags
- EMPTY the air from the bag
- ROLL the top of the bag down to the specimens
- TWIST the wire ends together, do not just fold them over the ends of the bags
- Gentle Reminder….TWIST TWIST TWIST THE ENDS TOGETHER
- Put in zip lock bag with a folded-up paper towel to keep any leaks in check

MAILING

- Every 2 sampling periods (once a month) mail the 2 whirlpaks to Sam Droege at the address at the top of the page
- Use a padded envelope in which you have the two whirlpaks (with labels inside), placed in a ziplock bag (with a paper towel inside), and to be very safe regarding leaks…all of this enclosed in a third ziplock
- Put in a paper copy of the log sheet (print from the provided Excel sheet) indicating which sampling periods are included

RECAP

1. Check once a week that traps are full of fluid
2. Strain out sample every 2 weeks
3. Write down in the log sheet whenever the contents of a trap are destroyed or missing
4. Put a label in the whirl pak indicating site and dates
5. Don't use too much glycol in bags (or they will leak)
6. Twist wire ends together firmly
7. Triple bag before mailing

PROPYLENE GLYCOL ISSUES

- Propylene glycol (PG) is a safe alternative to regular antifreeze (ethylene glycol) which is attractive to animals, but toxic
- PG appears NOT to be attractive to animals (based on many traps in woodlands and tests with Sam's dog, who has to live with PG traps all over the yard but ignores them…but eats everything else, particularly if it is dead)
- However, if an animal problem develops we will send you some dentonium benzoate which is a the world's most bitter substance and used to denature alcohol and car antifreeze

ACKNOWLEDGEMENTS

Many thanks to the 11 Forest Service Stations who participating in this pilot without compensation. Their feedback and results made this evaluation possible. Thanks also to the many people who have developed bowl survey techniques over the years; Frank Parker for his expansion from meat trays to party bowls and his thousands of bowl hours and Laurence Packer and Dave Smith for their work in using propylene glycol, and Emanuel Kula for his work on long-term sampling using bowl traps were particularly key. Also thanks to the many people who shared their experiences via that bee monitoring listserv and participated in endless unpaid experiments developing bowl survey techniques.

BIBLIOGRAPHY

Cameron, S.A., J.D. Loziera, J.P. Strange, J. B. Koch, N. Cordesa, L.F. Solterd, T.L. Griswold. 2011. Patterns of widespread decline in North American bumble bees. PNAS 108:662-667.